Thoughts on setting an energy measurement standard for injection moulding machines

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Feb 29, 2012

Introduction

A standard to measure energy consumption of injection moulding machines helps users to make purchase decision. What are the issues involved in setting up a good standard?

A good standard reflects the result of energy-saving features designed into the injection moulding machine. As energy consumption is affected by many conditions and parameters, sufficient number of them is to be held constant so the comparing results are meaningful. Conditions include the environment temperature. Parameters include machine parameters and moulding parameters.

The issues include the merits of a relative scale and an absolute scale, whether moulds are to be specified, why is it necessary to fix as many variables as possible, how machine design affects energy consumption, how to fix moulding parameters, and the importance of measurement accuracy

Two common standards are the Chinese industrial standard and Euromap 60. Is yet another standard necessary?

Classification by technology

Four types of drive technologies provide a rough idea of energy consumption of an injection moulding machine. They are

1. fixed displacement pump,
2. variable displacement pump,
3. servomotor/pump,
4. fully electric machine.

The first two types of pumps are driven by the common asynchronous motor, which is inexpensive and robust. Asynchronous motor rotates at near constant speed during the moulding operation.

Fixed displacement pump does not save on energy consumption during periods of slow motion. This is not so for variable displacement pump. Being able to stop and start at will, servomotor does not consume energy during idle periods when it is stopped. It also saves power when it slows down vs an asynchronous motor that does not. Furthermore, using permanent magnet instead of current to generate magnetic field, servomotor reduces the copper and iron losses of an asynchronous motor. That is, servomotor has a higher efficiency.

A fully electric machine does not use hydraulic oil and has at least four servomotors to drive injection, plasticizing, mould open/close and ejection mechanically. The energy to compress the oil is avoided. Multiple drives enable parallel motion which reduces cycle time.

Variations of the above 4 technologies exist. For example, closed loop variable displacement pump saves an additional 5% energy vs its open loop counterpart. There are hybrid machines that use variable displacement pump and direct servomotor drive at the same time.

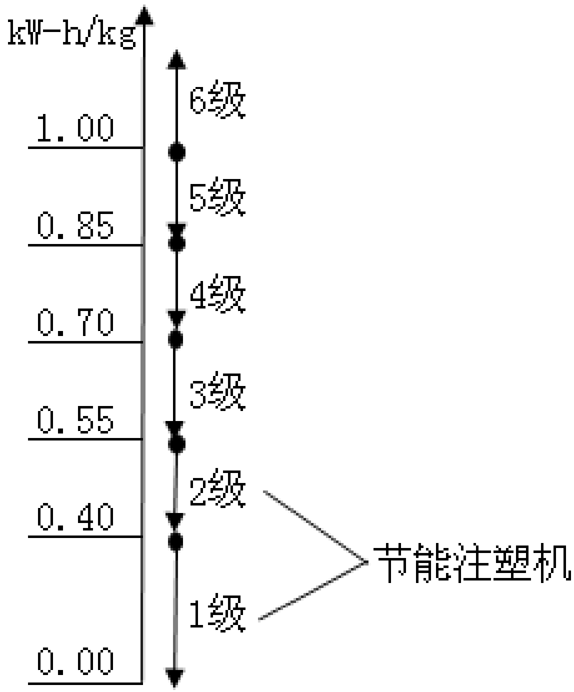
Barrel heating consumes about 1/4 to 1/3 of the energy of an injection moulding machine. Energy saving is possible by the use of a well-insulated barrel cover to reduce heat loss. Induction heating is a recent technology that generates heat within the steel material of the barrel. As a result, less heat is lost. Recycling the barrel heat to dry resin has also been used to reduce the electricity bill.

Such technologies provide a relative ranking of energy consumption. No energy-saving values could be attached to the machines using these technologies.

Relative scale vs absolute scale

The Chinese industrial standard categorizes a machine into one of six classes. A class 1 machine consumes less than or equal to 0.4 kW-h/kg of PS material. A class 6 machine consumes more than 1 kW-h/kg. This standard therefore provides a relative scale from class 1 to class 6. Each of classes 2 to 5 is 0.15 kW-h/kg wide. The class delimiters form an arithmetic (linear) series.

This standard specified machines in classes 1 and 2 are energy-saving machines. A relative class like this does give the layman a sense of how energy-saving is the machine, but it also has problems.



The problem with a relative scale by class is quantization. A machine at 0.40 kW-h/kg is class 1. A machine at 0.41 kW-h/kg is class 2. One wonders whether the conditions of the tests were held constant enough, and whether measurement accuracy is good enough to tell 0.01 kW-h/kg apart. We recommend the measurement of kW-h be accurate to 2 significant figures and the measurement of kg to 3 significant figures.

Another problem of class quantization is there is no class below class 1. Servomotor/pump machines using #3 mould could attain class 1. If the more energy-saving fully electric machine is also class 1, it could not be distinguished from a servomotor/pump machine.

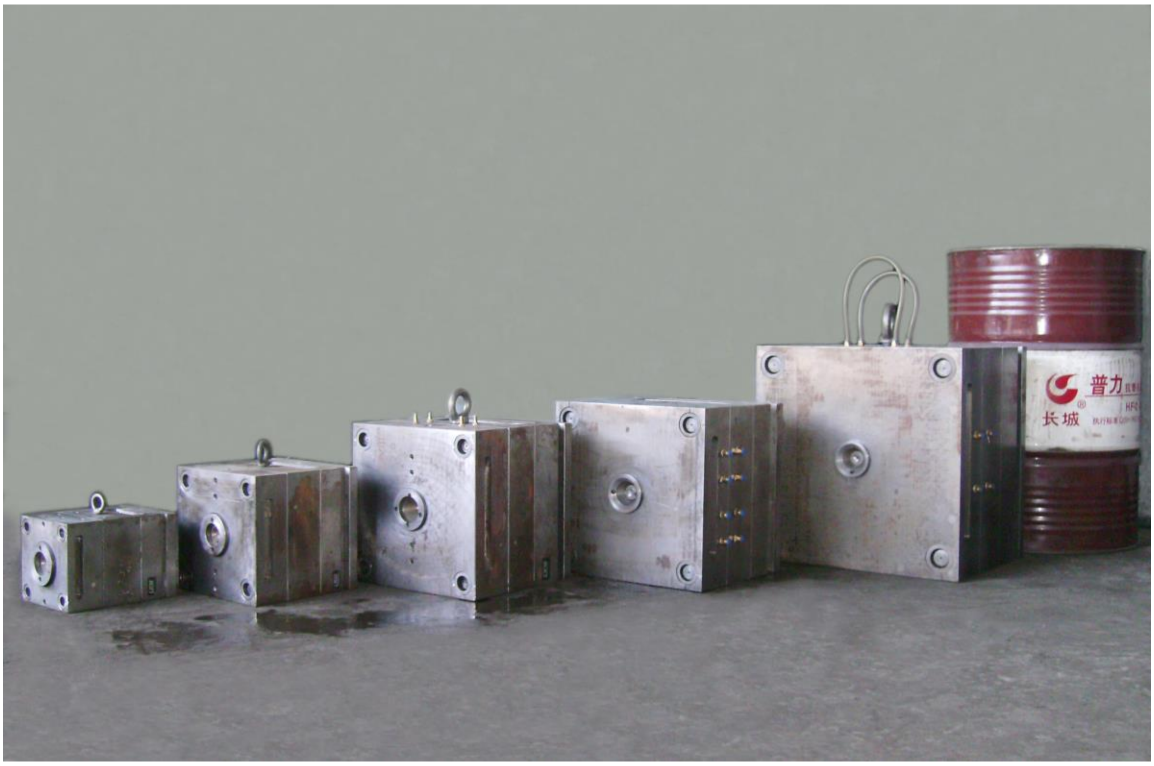
Euromap 60 uses an absolute scale. Machines are specified to consume so and so kW-h/kg of PP material. An absolute scale lets a user estimate the electricity bill when quoting for a job using similar plastic material and moulding parameters.

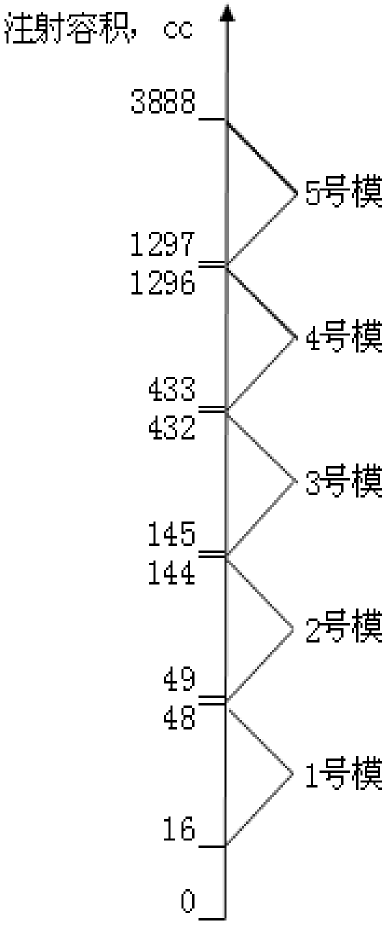
An absolute scale is not user friendly. Just looking at 0.4 kW-h/kg does not give a layman any idea how energy-saving the machine is.

Euromap 60 also specified the average power consumption of the machine in kW and power factor. They are also absolute values. In many countries, power factor does affect the electricity bill.

Mould or no mould

Euromap 60 did not specify any moulds. On the other hand, the Chinese industrial standard specified 5 moulds named #1 to #5 moulds to cover the range of injection moulding machines from 16 to 3888 cc shot volume.





When moulds are not specified, moulding parameters have to be specified to make the test comparable from one machine to another. Euromap 60 divides all mouldings into three types of cycles for thin-wall parts, technical parts and commodity parts/thick-wall parts. In each cycle, clamping and injection unit parameters are specified. Some are specified as the maximum possible of the machine, others are set according to a formula related to the maximum clamping force of the machine or its screw diameter. Some parameters are specified not as single values but as ranges. Values in the range could be selected to favour energy consumption. So long as the optimization is done in both tests, the comparison of two machines is fair.

A dummy mould is used in Euromap 60. The dummy mould is specified by Euromap 7.

One of two nozzles is specified by Euromap 60 to provide resistance to the melt during injection.

Merits and demerits of specifying moulds

When the moulds are specified in the standard, most of the moulding parameters do not have to be specified as long as the moulded parts are good parts. Good parts are defined not to have bubbles, flashes, sink marks, distortions, are homogenous and have consistent weight from shot to shot. However, quality attributes could not be quantified.

The problem of using moulds is quantization. Five single-cavity sprue-gated moulds are specified to cover machine shot volume from 16 cc to 3888 cc. Micromoulding machines and really big machines have no specified moulds to use.

Why only five moulds were specified to cover this range? It is a matter of convenience vs cost. The use of geometric (logarithmic) scale divides the big range of shot volume (3888/16 = 243) into five subranges to be covered by five moulds. The upper shot volume of each mould is 3 times its lower shot volume. $3*3*3*3*3 = 3^5 = 243$.

The 3x range of shot volume covered by each mould is very wide. #3 mould covers machines from 75 tons to 150 tons of clamping force using the B screws. If more moulds were specified, a smaller range of machines using the same mould will facilitate comparison, but the cost of all the moulds would be higher.

Another problem of specifying moulds is how representative the moulds are of what customers are using. The five moulds specified by the Chinese industrial standard are cold runner sprue-gated 2-plate moulds each at one cavity. Due to the specification of brittle PS, semi-automatic operation or fully automatic operation using a robot takeout arm has to be used. Free-drop fully automatic operation, 3-plate multi-cavity moulds, hot runner moulds, cold runner moulds not using sprue gates, are not represented by the specified moulds.

The Chinese industrial standard really specified the parts but not the moulds themselves. The size of the mould, the mass of the moveable mould, etc. are not specified. They do affect whether the moulds could be fitted into the machine under test, the acceleration and deceleration of the moveable platen, etc.

Euromap 60 specified the test mould according to Euromap 7. The size and mass of the test mould are therefore specified. In Euromap 7, the 1-piece test mould is mounted on the fixed platen and therefore its mass does not affect moveable platen acceleration/deceleration.

What is the metric to compare?

For the reason that a big machine consumes more energy per hour than a small machine does, simply measuring kW-h and figuring out kW-h/h cannot tell whether it is a wasteful small machine or an energy saving big machine. Actually kW-h/h is the average (over an hour) power in kW of the machine, and obviously a big machine consumes more power than a small one.

On a particular machine and mould, the kW-h/h figure will change if cycle time is changed due to moulding parameter change. If cycle time is reduced, more parts will be produced and therefore more energy will be consumed per hour. How do we get rid of the dependence on cycle time? What about energy consumed per shot?

If the metric is kW-h/shot, one has to define what constitutes a shot.

If the standard specified moulds, are the two machines using the same mould? It would only be fair that they use the same mould, but as we have seen above, a mould covers a big range of machine sizes. In this case, the shot is constant for the two machines but would be a bigger percentage of the machine shot weight for the smaller of two machines. It penalizes the smaller machine as it takes more energy for the small machine to plasticize the same amount of material using a smaller screw. The same applies to injection.

If the standard did not specify any moulds, a big machine has a bigger shot than a small machine and therefore penalizes the bigger machine.

Both the Chinese industrial standard and Euromap 60 use kW-h/kg as a metric of energy consumption. Among the metrics

1. kW-h
2. kW-h/h
3. kW-h/shot

kW-h/kg seems to be the best. However, measurements have shown that it is easier to get a low kW-h/kg figure with a big machine (using a big mould) vs a small machine (using a small mould.

A big machine (using #5 mould) with a variable displacement pump can get class 1 energy consumption but a small machine (using #1 mould) with a servomotor can only get class 2.

To avoid this problem, the class delimiters could vary across the range of machine/mould sizes. For example, for #3 mould, the class 1 upper limit is 0.4 kW-h/kg. This could be raised for #2 mould and even more for #1 mould. Similarly, it could be lowered for #4 and even more for #5 mould.

Even if the same mould is used, the mould spans a big range of shot weights. A machine near the high end of the range has an advantage over a machine near the low end of the range. This is due to the higher efficiency of plasticizing one kg of material by the bigger machine. There are fewer mould openings to get one kg of parts too.

These issues are specific to a standard that specify moulds. They are also specific to the standard that specified relative classes. Euromap 60 does not have these problems.

Euromap 60 also includes the kW-h/h value in the form kW. It is the average power consumption of the machine over the duration of the test.

As Euromap 60 also indicates cycle time, kW-h/shot could be calculated from average power and cycle time.

Machine parameters

1. Screw diameter

Most injection moulding machines have a choice of three screw diameters. The screws are known as A, B and C screws. A screw has the smallest diameter and C screw has the biggest diameter. The standard screw is the B screw.

In our tests, we have found that on the same machine and using the same mould, energy consumption per kg is smallest if the C screw is used. It is the highest if the A screw is used.

Because of this dependence, we do not recommend to specify a machine by the common practice of clamping force, as far as energy consumption comparison between machines is concerned. By the reason shown in the next section, we also do not recommend to specify a machine by shot volume or shot weight. We recommend to use screw diameter instead. That is, a brand A machine should be compared o a brand B machine of the same or similar screw diameter as far as energy consumption is concerned.

A few Euromap 60 moulding parameters are specified to be functions of screw diameter.

2. Shot volume

Shot volume is the product of the screw cross section area and injection stroke. Injection stroke ranges from 3.5 D to 5 D, where D is the screw diameter. The higher is the injection stroke, the lower is the quality of the melt. The use of shot volume (or its relative shot weight) to specify a machine would involve quality which is hard to quantify. The use of screw diameter would not.

Euromap 60 has indirectly specified shot volume of =<12.5%, =<50% and =<75% of machine shot volume for the three types of cycles.

3. L/D ratio

Everything else the same, the higher the L/D ratio, the better is the melt quality, but more energy is needed to plasticize one kg of material since more torque is needed. In this case, the price of quality is paid for by more energy consumed per kg as well as on the relative scale.

4. System pressure

Due to a lower barrel temperature, the use of a viscous material or the wrong use of C screw, the screw motor could be working at system pressure, which could be from 140 to 175 kg/cm2. In this case, the motor is ‘maxed’ out, not being able to provide sufficient torque to turn the screw at the rpm set by the user. We have reasons to believe energy consumption per kg is higher in this case due to the longer plasticizing time. System pressure does have an effect here. This is an inherent machine characteristic that gives it a lower rating than an identical machine with a higher system pressure.

5. Direct hydraulic clamp

A direct hydraulic clamp machines does consume more energy than an identical toggle machine due to a larger amount of hydraulic oil being compressed. The energy of compression cannot be recovered to do useful work. This is an inherent machine characteristic that determines its class in the relative and absolute scale.

6. Parallel motion

The purpose of parallel motion is to reduce cycle time. There are many types of parallel motions possible. The simplest and most common is eject-on-the-fly which hides the ejection time. With a nozzle shutoff valve, a machine with two power sources could plasticize at the same time the mould is opening/closing as well as ejecting. A holding pressure device allows plasticizing to start when holding pressure stage starts.

While more kg of material is processed per unit time, more energy is also consumed per unit time. It is estimated that parallel motion puts a machine at an advantage on the energy consumption scale. The reason is the same as in section 9, Bulk injection machine. This is an inherent machine characteristic that determines it on the scale.

7. Multi-material machines

A multi-material machine has at least two power sources and at least two heated barrels. Comparing a multi-material machine with a standard machine is really not apple to apple comparison. A position in the relative scale compared to a one-material machine is also not meaningful. One should compare a multi-material machine with another multi-material machine.

Both standards do not cover multi-material machines.

8. Accumulator-assisted injection

This is another special purpose machine to make thin-wall parts. It should only be compared to another accumulator-assisted machine. A position in the relative scale is not meaningful.

Please note that Euromap 60 has specified a type of cycle for thin-wall parts. The parts specified by the Chinese industrial standard are not thin-wall parts.

9. Bulk injection machine

This is a special-purpose machine to make thick-wall (like preforms) and bulky parts (like shoe soles). It should only be compared to another bulk injection machine. A position in the relative scale is not meaningful. It would score very well in the relative and absolute scale as there are many kilograms of material per shot. A big denominator gives a small kW-h/kg figure.

Please note that Euromap 60 has specified a type of cycle for thick-wall parts. For the Chinese industrial standard, the part thick of #3 mould is 2.7 mm. It is not considered thick-wall.

Fix as many variables as possible

Many variables affect the energy consumption in injection moulding. They have to be specified by the standard so comparison is meaningful.

1. Plastic material

The Chinese industrial standard specified PS for all but the biggest machines. For machines with shot volume above 3888 cc, PP is specified.

The Euromap 60 standard specified PP as the plastic material to use.

PS is brittle. The circular plates moulded by the Chinese industrial standard cannot free fall without breaking so either semi-automatic operation or robot arm removal has to be used. Both would complicate the purpose of measuring energy consumption. Semi-automatic operation introduces variation in cycle time.

Furthermore, PS is amorphous, PP is semi-crystalline, the latter involves latent heat of fusion when melting.

Although the MFR of PS was specified by the Chinese industrial standard and that of PP was specified by Euromap 60, a range was specified. If one grade of material from one supplier is specified, variation would be reduced. In particular, the enthalpy data of this material has to be known from environment temperature to barrel temperature. This sets the minimum energy consumption per kg possible for this material. A relative scale could use this value as ‘absolute zero’.

2. Environment temperature

The Chinese industrial standard specified an environment temperature 15 ~ 35 deg C. This is the range expected in factories in Zhe Jiang and Guang Dong provinces in China.

Euromap 60 specified a temperature below 30 deg C. This range is expected in factories in Europe.

Both ranges are too big to control variations of tests from one another. The higher the environment temperature, the less is the heat loss from the barrel. It is more advantages to perform the tests in summer than in winter.

Environment temperature has its effect felt at the water collar temperature and mould temperature as well. Air conditioning alone is not sufficient to control this variable from one test to another.

3. Environment air flow

Both standards do not specify environment air flow as caused by e.g. blowing fans. Air flow, including that caused by people walking by, carries away heat from the barrel and should be kept as little as possible,.

4. Mould temperature

Mould temperature affects holding pressure time and cycle time. When plasticizing is done but cooling is still continuing, a fixed displacement pump machine still consumes energy while a servomotor would have stopped. During the holding pressure time when a servomotor turns slowly, the servomotor gets hot very fast (and consumes energy).

The Chinese industrial standard did not specify mould temperature. Euromap 60 does not involve injection into a real mould.

The mould is a distributed system. One point representative of the mould temperature has to be designed. Mould temperature is not constant but varies over time within a range. It is highest soon after injection and is lowest when the mould opens. The use of hot runner complicates this issue. Regulating the water flow rate is one way to regulate mould temperature. For simplicity, it is recommended to use water tower water instead of chilled water or mould temperature controller to control mould temperature. Both the chiller and mould temperature controller consume power.

5. Water collar temperature and flow rate

A lot of heat is drained from the last barrel zone heater to the water collar due to the big temperature difference over a short distance. The lower is the water collar temperature, the more is the heat loss. The water collar temperature should be set at a narrow temperature range (e.g. 5 deg C) to facilitate comparison. Regulating flow rate is a simple and effective way to regular water collar temperature.

The Chinese industrial standard did not specify water collar temperature. It only require the inlet water temperature, outlet water temperature and water flow rate are to be recorded.

Euromap 60 did not mention water collar temperature or water flow rate.

6. Cycle time
Both standards do not specify cycle time. Euromap 60 requires cycle time to be indicated.

Cycle time affects energy consumption in the following way.

When a platen accelerates from rest, it takes energy from the drive which is usually not recovered. The bigger is the acceleration, the more is the energy needed and the shorter is the cycle time. In big machines, a few manufacturers have designed a system to recover some kinetic energy during deceleration.

Other motions like injection and ejection also involve acceleration. Since the mass involved is much less than that of the moveable platen and the mould half mounted on it, the kinetic energy is also smaller.

Customers welcome short cycle time but have to realize a price has to be paid for it.

Specifying cycle time or movement speed would make comparisons fair. Euromap 60 specified max. mould opening/closing speed and max. mould opening/closing acceleration/deceleration of the machine are to be used. For thin-wall cycle, Euromap 60 specified injection time. For technical parts and commodity/thick-wall cycle, injection speed of the machine is specified.

Euromap 60 also specified ejection speed, holding pressure time and cooling time.

Moulding parameters
The Chinese industrial standard set very few moulding parameters. The molding parameters are to be set to make good parts.

Without specifying moulds, Euromap 60 set many moulding parameters.

1. Barrel temperature settings
The Chinese industrial standard set the barrel temperature at 250 +- 10 deg C. The range is wide. It is assumed that this applies to all barrel zones (including nozzle)

Euromap 60 sets the barrel temperature at 220 deg for all barrel zones. No temperature range is specified. It is assumed this is also the nozzle temperature. Maximum temperature variation is +- 3 deg C within 30 minutes.

2. Back pressure

Euromap set back pressure at 50 +- 5 bars. Note that this is the pressure at the melt, not the pressure displayed on the back pressure gauge which is hydraulic pressure. A converter from back pressure gauge reading to melt pressure is available from the manufacturer.

3. Plasticizing pressure

Both standards have not set plasticizing pressure. We recommend setting it to system pressure so plasticizing pressure is at or below system pressure depending on the resistance of the melt to screw rotation.

4. Plasticizing time/speed

Both standards have not set plasticizing time or plasticizing speed. We recommend to set plasticizing speed (rpm) to maximum (100%). Plasticizing time will be the result of plasticizing an amount of material (see below) at max. plasticizing speed.

5. Metering stroke/injection stroke

Euromap 60 has set metering stroke to =< a value which is a function of screw diameter d. This value is different for the three types of cycles.

	Thin-wall parts	Technology parts	Commodity/thick-wall parts
Metering stroke	=< 0.5 d	=< 2d	=< 3d

To reduce kW-h/kg, it is recommended to take the equality to maximize shot weight. This enables one kg to be injection moulded in fewer shots.

6. Injection pressure

Euromap 60 has set injection pressure for the three types of cycle as shown below.

	Thin-wall parts	Technology parts	Commodity/thick-wall parts
Injection pressure	>= 1000 bar	>= 750 bar	>= 500 bar

To reduce kW-h/kg, it is recommended to take the equality to reduce the energy consumed during injection.

7. Injection time/speed

Euromap 60 specified injection time for thin-wall parts. Injection speed was specified for the other two types of cycle.

	Thin-wall parts	Technology parts	Commodity/thick-wall parts
Injection time	=< 0.1 s	Not specified	Not specified
Injection speed	Not specified	=< 50% of max.	=< 50% of max.

8. Holding pressure

Euromap 60 has set holding pressure at >= 50% of injection pressure for all three types of cycle.

9. Holding pressure time

Euromap has set holding pressure time with a tolerance.

	Thin-wall parts	Technology parts	Commodity/thick-wall parts	Tolerance
Holding time	0 s	5 s	10 s	+- 0.1 s

10. Cooling time

Euromap 60 has set cooling time to be constant or a function of screw diameter d (in mm) for the three types of cycle.

	Thin-wall parts	Technology parts	Commodity/thick-wall parts
Cooling time, s	>= 0.5	>= 5 + 0.1 * d	>= 10 + 0.2 * d

To reduce kW-h/kg, it is recommended to use the equality to reduce cooling time.

11. Cycle time

Both standards do not specify cycle time. Cycle time is to be indicated as a Euromap 60 value.

Euromap 60 mentioned that parallel movement to reduce cycle time is allowed. This is usually the case in a fully electric machine moulding cycle.

12. Clamping force

The Chinese industrial standard did not specify clamping force. One would use the minimum possible not to produce flashing. Euromap 60 specified the maximum clamping force is to be used.

13. Opening stroke

The Chinese industrial standard did not specify opening stroke. One would use the minimum possible to reduce energy consumption and cycle time.

Euromap 60 uses a formula which depends on the clamping force (in kN).

	Thin-wall parts	Technology parts	Commodity/thick-wall parts	Tolerance
Opening stroke, mm	S = 150 + 800* (clamping force – 1000)/9000 when 150 =< S =< 1000			+- 0.5%

The minimum opening stroke is 150 mm (for a small machine). The maximum opening stroke is 1000 mm (for a big machine).

14. Closing/opening speed

Euromap 60 specified the maximum value.

15. Clamping acceleration/deceleration

Euromap 60 specified the maximum value.

16. Ejection stroke

Euromap 60 specified >= 50% maximum stroke.

To reduce kW-h/kg, use the equality.

17. Ejection speed

Euromap 60 specified the maximum value.

18. Ejection force

Euromap 60 specified no load.

Instrumentation and test duration

The Chinese industrial standard specified instrument accuracy at +- 1%. It specified

50 shots for all five moulds.

From our test data on machines using the five moulds, the test durations are listed in the table below.

	Cycle time, s	Test duration, minutes	kW-h in 50 shots
#1 mould	12.45	10.4	0.6
#2 mould	19.27	16.1	0.7
#3 mould, machine 1	20	16.7	1.6
#3 mould, machine 2	28.9	24.1	1.7
#4 mould machine 1	36	30	3.9
#4 mould machine 2	40	33.3	4.5
#5 mould	70.5	58.75	15.71

Test duration ranges from 10.4 minutes for #1 mould to almost an hour for #5 moulds. kW-h for 50 shots ranges from 0.6 to 15.71 kW-h.

#1 mould has the lowest energy consumption at 0.6 kW-h/50 shots. 1% of 0.6 kW-h is 0.06 kW-h. The resolution of the power meter to 0.01 kW-h is needed.

Power meter with 0.01 kW-h resolution

Power meter with 0.1 kW-h resolution

Energy consumed/50 shots is the difference of final power meter reading and initial power meter reading. To reduce power meter reading error, it is recommended to zero the power meter before each test.

Euromap 60 specified instrument accuracy at +-2%. It specified a number of consecutive shots in >= 10 minutes and at least 5 shots. For screw diameter >= 80 mm, 3 shots are sufficient.

Separation of drive energy from heating energy

Depending on the drive, barrel heating takes up 1/4 to 1/3 of the energy consumption of an injection moulding machine. New technologies like induction heating have emerged to save barrel heating energy. It is recommended to measure drive energy consumption and heater energy consumption separately for the following reasons.

1. It makes comparison of drive technologies possible if two machines use different barrel heating technologies.
2. It makes comparison of barrel heating technologies possible.
3. It helps users decide whether to purchase the barrel heating technology as an option.
4. Heater energy consumption being a fraction of the total energy consumed, higher resolution than 0.01 kW-h is needed.
5. Motors are three-phase and requires 3-phase power meters. Heaters are single phase. They are distributed on the three phases to balance the phases. Multiple single-phase power meters each with 0.001 kW-h resolution could be used to measure heater energy consumption in 50 shots.
6. As the common barrel heaters are resistive, we have found that measuring the ON duration of each heater during the test and its ON current provides an accurate estimate of energy consumption which could be checked against that measured by single-phase power meters. Furthermore, the resolution is sufficient.

Take the 1 kW barrel heater of a small machine (that uses #1 mould) as an example. Powered by 220 V, its ON current is 4.55 A. A clamp meter could measure current to 3 significant figures. Similarly, a digital voltmeter could measure voltage to 3 significant figures. If ON time could be measured with 1 s resolution, the energy consumed in 10 minutes, assuming the heater is ON 100% of the time, is 220 V* 4.55 A* 10/60/1000 = 0.167 kW-h. This is 0.001 kW-h resolution.

The nozzle heater of a small machine at 0.3 kW draws a current of 1.36 A. Its energy consumption in 10 minutes is 0.0499 kW-h. This is 0.0001 kW-h resolution.

A single-phase power meter is needed per heater zone, including the nozzle heater. A machine with a nozzle heater and three barrel heater zones requires 4 single-phase power meters.

With such a separation in measurement, what about the energy consumption of computer controller, cooling fans, lubrication pump, etc.? It could be measured separately using yet another single-phase power meter or for convenience lumped into the 3-phase power meter of the drive.

Comparing the two standards

Since Euromap 60 did not specify any moulds, many moulding parameters have to be specified to make comparison with another machine meaningful.

By specifying moulds, the Chinese industrial does not need to specify many moulding parameters so long as the parts are good parts, like no flashes (sufficient clamping force), no bubbles (sufficient back pressure), no sink mark (sufficient holding pressure and time), etc. Quality of the parts cannot be quantified. There is room for users to tweak moulding parameters to improve the machine class rating.

Euromap 60 specified three types of cycles with their own moulding parameters. One would only compare two machines making the same type of parts in the same type of cycle.

In the Chinese industrial standard, the parts are discs with thickness t from 1 to 4.77 mm and flow length L 58 mm to 235.7 mm. L/t ratio is less than 64. All five parts could be classified into the Euromap 60 commodity/thick-wall part type of cycle. There is no provision for thin-wall parts and technical parts. Otherwise, 10 more moulds are needed.

The Chinese industrial standard contains quantization in two areas: mould and class.

According to machine shot volume (not clamping force, not screw diameter), a mould out of five is selected to do the testing. Machines with a big range of shot volumes share the same mould. This favours machines with big shot volumes, so a machine with C screw outdoes the same machine with A screw.

In Euromap 60, a few moulding parameters are functions of screw diameter to make the comparison fair. This includes metering stroke and cooling time. Opening stroke is dependent on clamping force. Other moulding parameters that are dependent on machine parameters includes clamping force, clamping speed, clamping acceleration/deceleration, ejector stroke, ejector speed, injection speed and holding pressure,

The Chinese industrial standard introduces 6 classes of energy consumption which produces another quantization. Instrumentation accuracy of +-1% is needed to tell 0.40 kW-h/kg from 0.41 kW-h/kg as the former is class 1 but the latter is class 2. It was discovered that class delimiters should vary from small machines/moulds to big machines/moulds to make classes comparable for small as well as big machines. Otherwise, a big machine based on variable displacement pump getting class 1 but a small machine based on servomotor getting class 3 is confusing to the customer.

The two standards are as different as East and West. Could yet another standard combine the best of both standards?

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