

DESING OF PLASTIC PRODUCTS

Compiled by: Titova E.Yu., Gr. ХТМП-116
Supervisor: professor Fedulenkova T.N.

Vladimirsky State University
Vladimir, 2016

- The times we live in are often known as the “Computer Age.” It could also be referred to as the “Plastics Age,” as the production of plastics has exceeded that of steel (by volume) since 1979. In fact, the volume of plastics produced has more than doubled in the last 20 years. Nonetheless, most students who graduate from the major engineering universities are generally unprepared generally unprepared to design to design in plastics. Thus, it is left to the individual engineer to learn plastics engineering on his or her own, often by trial and error.






UNLIKE METALS, THE PROPERTIES OF MOST PLASTICS VARY CONSIDERABLY WITHIN NORMAL OPERATING TEMPERATURES. A PARTICULAR ACRYLONITRILE BUTADIENE STYRENE (ABS) WHOSE TENSILE STRENGTH IS 5500 LB/IN² AT ROOM TEMPERATURE CAN DROP TO 2800 LB/IN² AT 125 °F. OTHER PROPERTIES ARE ALSO AFFECTED. FOR EXAMPLE, BRITTLENESS INCREASES AS THE TEMPERATURE DROPS, ETC.



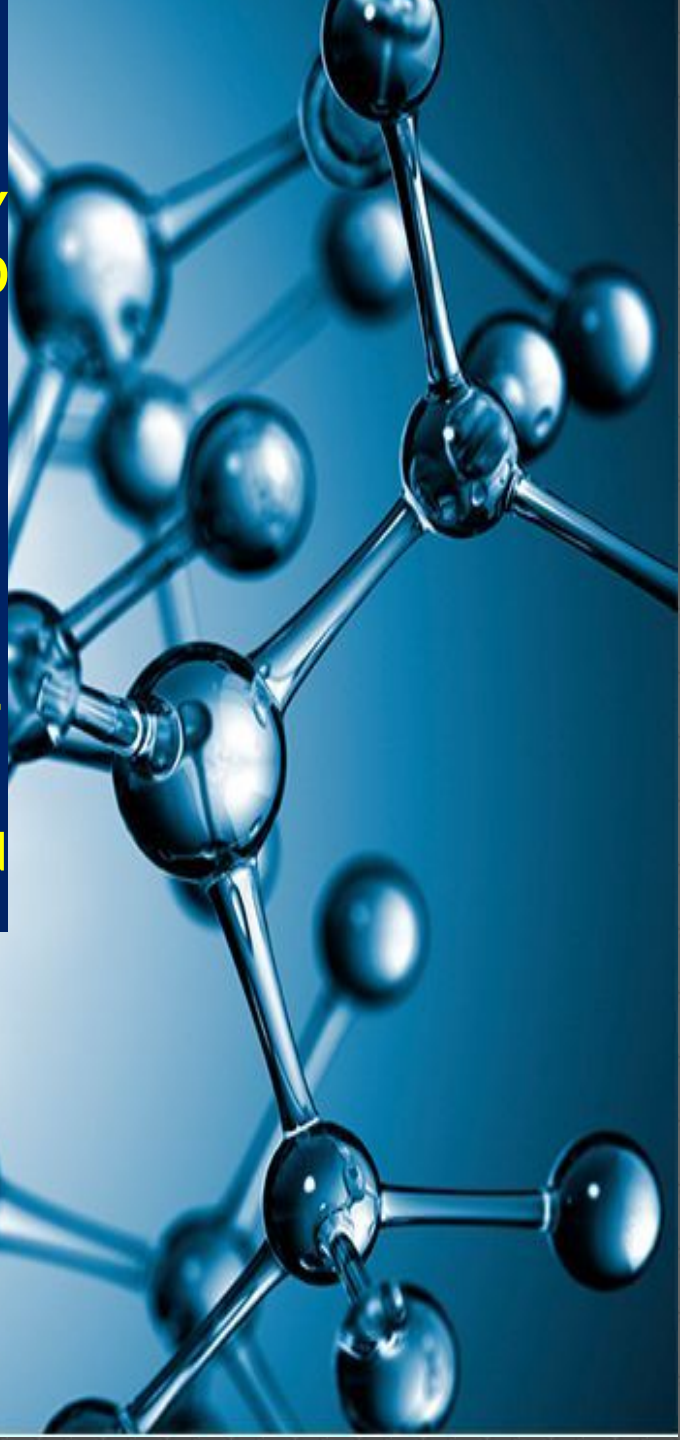
**WHAT DOES THIS
MEAN TO THE DESIGN
ENGINEER?
BASICALLY, IT MEANS
THERE WILL BE MORE
WORK TO DO.**

It cannot be assumed that the product will survive the temperatures endured in cleaning, shipping, or storage unscathed.



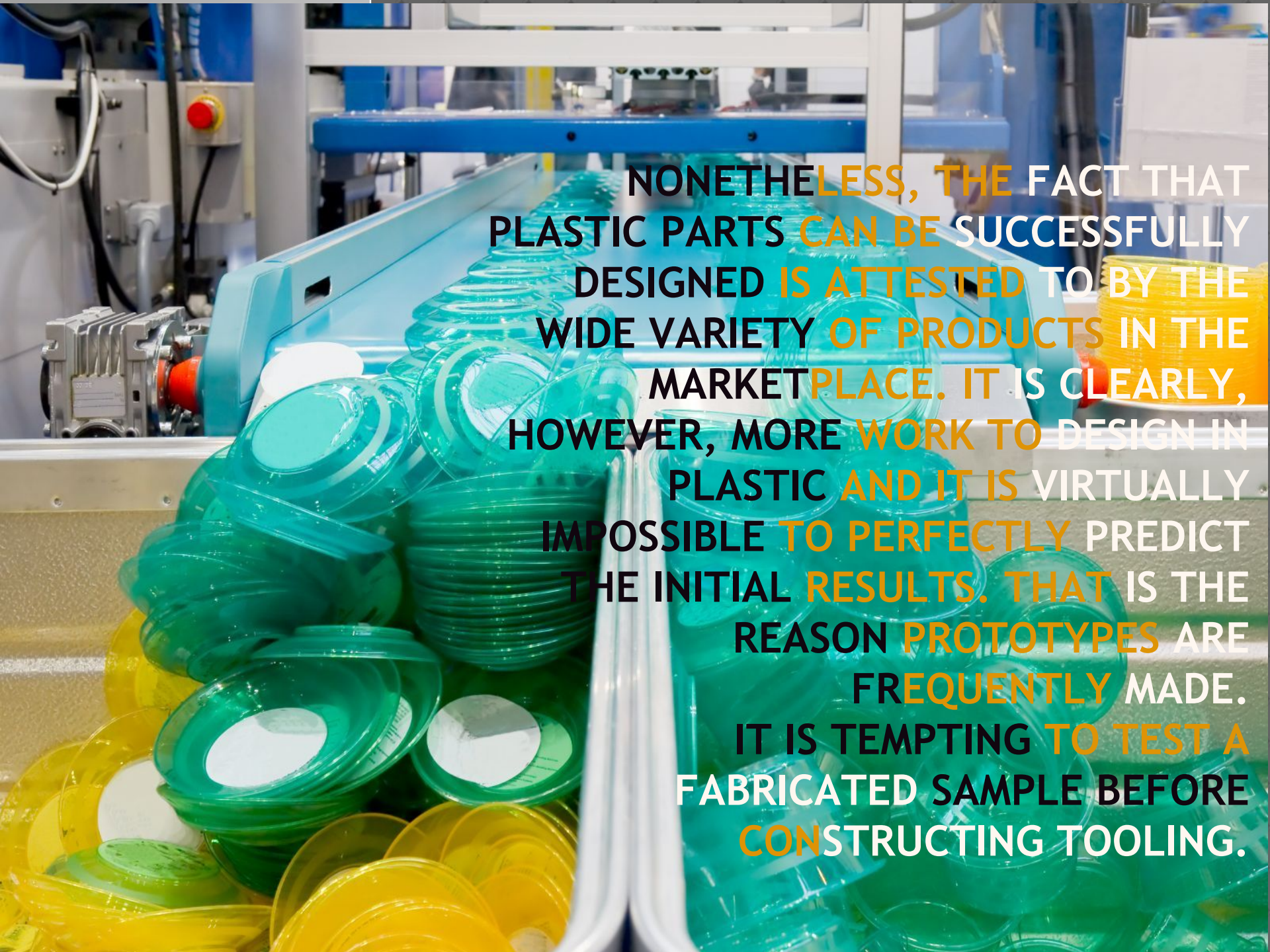
OTHER EXPOSURES CAN CAUSE PROBLEMS WITH PLASTIC COMPONENTS AS WELL. ULTRAVIOLET LIGHT CAUSES OR CATALYZES CHEMICAL DEGRADATION IN MANY RESINS. PLASTICS ARE VULNERABLE TO ATTACK FROM MANY CHEMICALS, PARTICULARLY IN HEAVY CONCENTRATIONS. SOME ARE EVEN AFFECTED BY WATER AND THERE IS ONE, POLYVINYL ACETATE, THAT ACTUALLY DISSOLVES IN WATER (FOR EXAMPLE, SOAP, PACKETS).

THAT IS NOT TO SUGGEST ANY SKULLDUGGERY ON THE PART OF THE TEST ENGINEERS; IT IS SIMPLY THAT THE STANDARD TEST SAMPLE AND CONDITIONS ARE NARROWLY DEFINED AND LIKELY TO BE SIGNIFICANTLY DIFFERENT FROM THOSE TO BE ENDURED BY ANY SPECIFIC PRODUCT. THE VALUES OBTAINED FOR MOST PLASTICS WILL VARY ACCORDING TO THE PROCESS, GATING, WALL THICKNESS, RATE OF LOADING, ETC. IT SHOULD BE NOTED THAT THERE IS SOME LATITUDE WITHIN THE TEST PROCEDURES THEMSELVES WHICH CAN AFFECT RESULTS. MOST PLASTICS ENGINEERS USE THE DATA SHEETS PRINCIPALLY FOR THE PURPOSES OF COMPARISON IN MATERIAL SELECTION.





EVEN IF THE MATERIAL MAINTAINED ITS PROPERTIES THROUGHOUT THE PRODUCT'S TEMPERATURE RANGE AND THE DATA WAS PERFECTLY RELIABLE, THE PRODUCT'S PERFORMANCE COULD STILL VARY. THAT IS BECAUSE THE PLASTICS PROCESSES ARE SUBJECT TO TOOLING QUALITY AND PROCESS PARAMETER VARIATIONS.



NONETHELESS, THE FACT THAT PLASTIC PARTS CAN BE SUCCESSFULLY DESIGNED IS ATTESTED TO BY THE WIDE VARIETY OF PRODUCTS IN THE MARKETPLACE. IT IS CLEARLY, HOWEVER, MORE WORK TO DESIGN IN PLASTIC AND IT IS VIRTUALLY IMPOSSIBLE TO PERFECTLY PREDICT THE INITIAL RESULTS. THAT IS THE REASON PROTOTYPES ARE FREQUENTLY MADE. IT IS TEMPTING TO TEST A FABRICATED SAMPLE BEFORE CONSTRUCTING TOOLING.

BASIC DESIGN CONSIDERATIONS



In order to avoid unpleasant surprises which can cause a design to fail, it is necessary to know everything possible about the conditions which the product will be exposed to in its lifetime. Armed with that information, the plastics designer can determine if the design, material, process, and tooling are appropriate for the application.



A CERTAIN DEGREE OF RISK IS INHERENT IN PLASTICS DESIGN BECAUSE THE COST IN TIME AND RESOURCES IS TOO GREAT TO PERMIT THE ACCUMULATION OF ENOUGH INFORMATION TO ELIMINATE THAT RISK. HIGHER LEVELS OF RISK ARE ACCEPTABLE WHERE TOOLING INVESTMENT IS LOW AND WHERE PRODUCT FAILURE RESULTS ONLY IN VERY LOW LEVELS OF PROPERTY LOSS. AS THE COST OF FAILURE INCREASES, MORE RESOURCES ARE DEVOTED TO RISK REDUCTION AND GREATER SAFETY FACTORS ARE USED. WHEN PRODUCT FAILURE COULD RESULT IN SERIOUS INJURY OR LOSS OF LIFE, EXHAUSTIVE TESTING AND GREATER SAFETY FACTORS ARE EMPLOYED.

PROCESS SELECTION

Plastics product designers are primarily interested in the ability of a given process to produce the shape they require. Therefore, the processes have been grouped according to their ability to produce a given shape. The groupings are 1)thermoplastic open shapes; 2)thermoset open shapes; 3)hollow parts; 4)profiles; 5)ultra high strength.

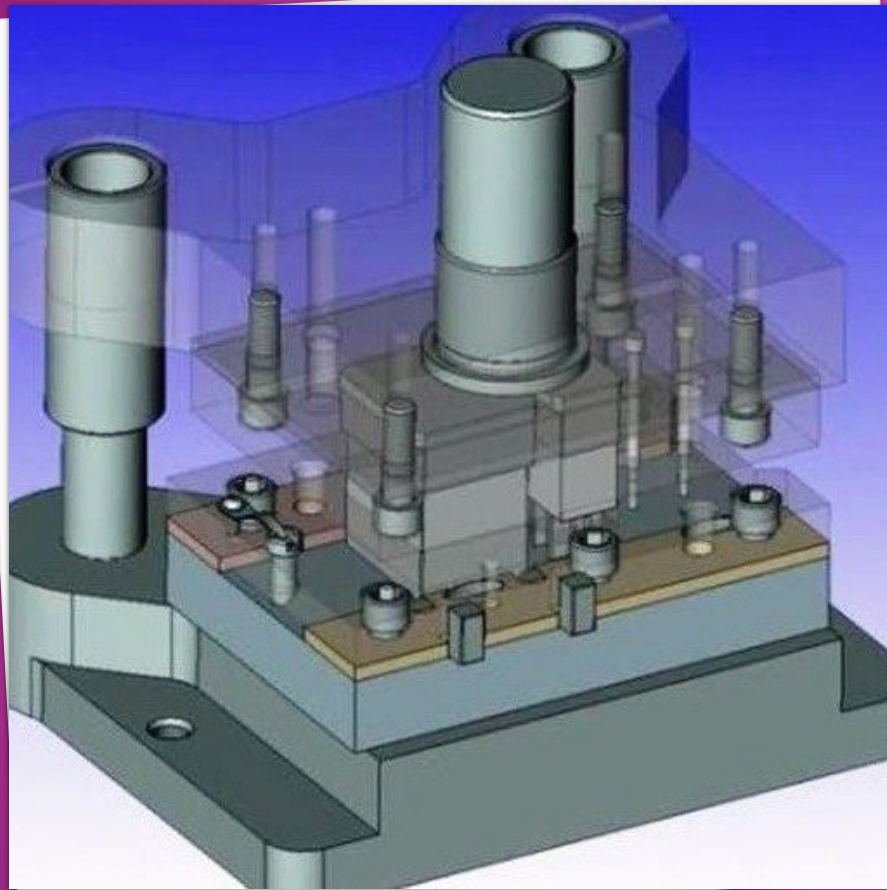
PROCESS SELECTION

- Beyond the fundamental design requirements, cost becomes the most significant factor in selecting the optimum process for the application. Product cost has three interrelated components: part cost, labor cost, and tooling amortization. Labor is related to process selection because some plastics processes permit the combining of parts to eliminate labor cost.

- As a broad statement, processes that require a higher initial investment in tooling produce parts at a lower cost. This is largely due to the fact that the reduced part cost is the product of faster molding cycles. Faster cycles require pressure on the plastic to reduce the time required to fill the mold cavity. The greater the pressure, the stronger the tooling and the more sophisticated the processing equipment must be. Both of these are factors which increase the initial investment.



The product design engineer is, therefore, keenly interested in the volume at which the additional investment would be justified by reduced part cost. It would simplify the decision making tremendously if it were possible to determine that point in terms of a given volume for each process. That might be feasible if all parts were identical in shape and size.



One may presume that the larger and/or more complex the part, the greater the investment will be. As the investment grows, the production volume must be greater in order to pay the difference with lower piece part costs within an acceptable time period.

DESIGN FOR MULTIPLE PART ASSEMBLIES

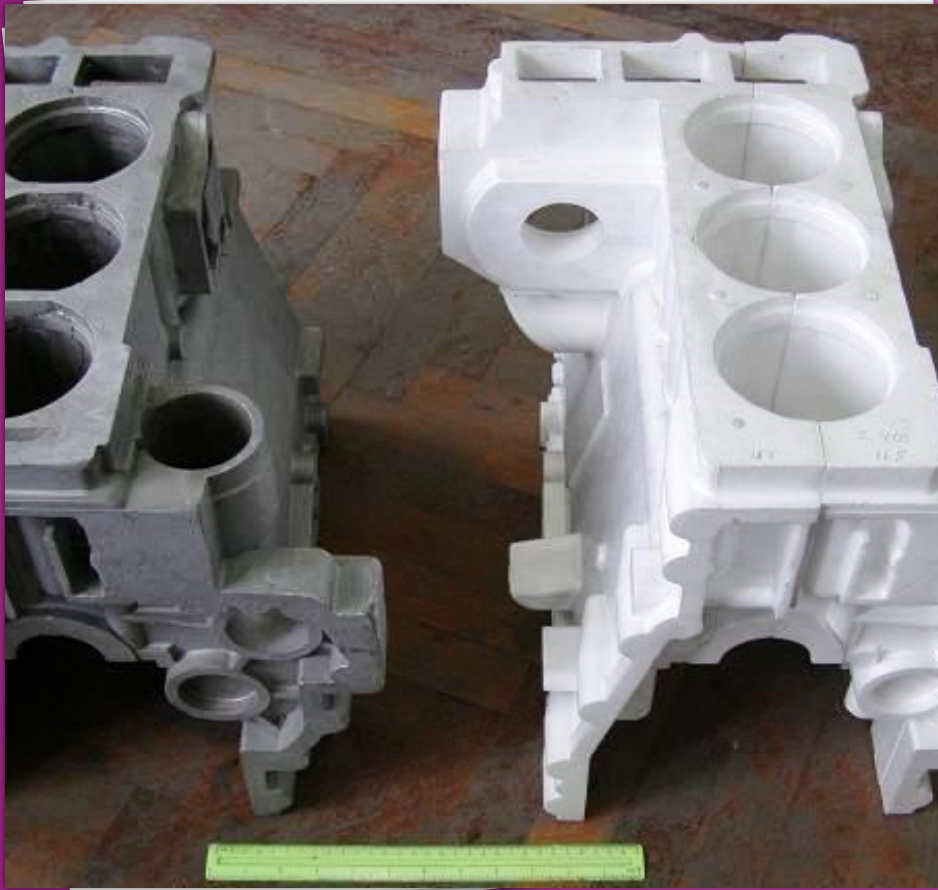
- The first step is to ensure that the parts fit together properly—not merely at room temperature, but at the temperature extremes of what the product may be expected to encounter. For example, a force fitment that works perfectly at room temperature may loosen at elevated temperatures or fracture at low temperatures.

DESIGN FOR MULTIPLE PART ASSEMBLIES

- That involves the determination of the fitments after the relationship of the parts to each Design of Plastic Products other has changed due to differences in the coefficient of linear thermal expansion. Thus, the establishment of acceptable dimensional limits, generally known as tolerances, for the fitment dimensions is of critical importance according to variations in process parameters.

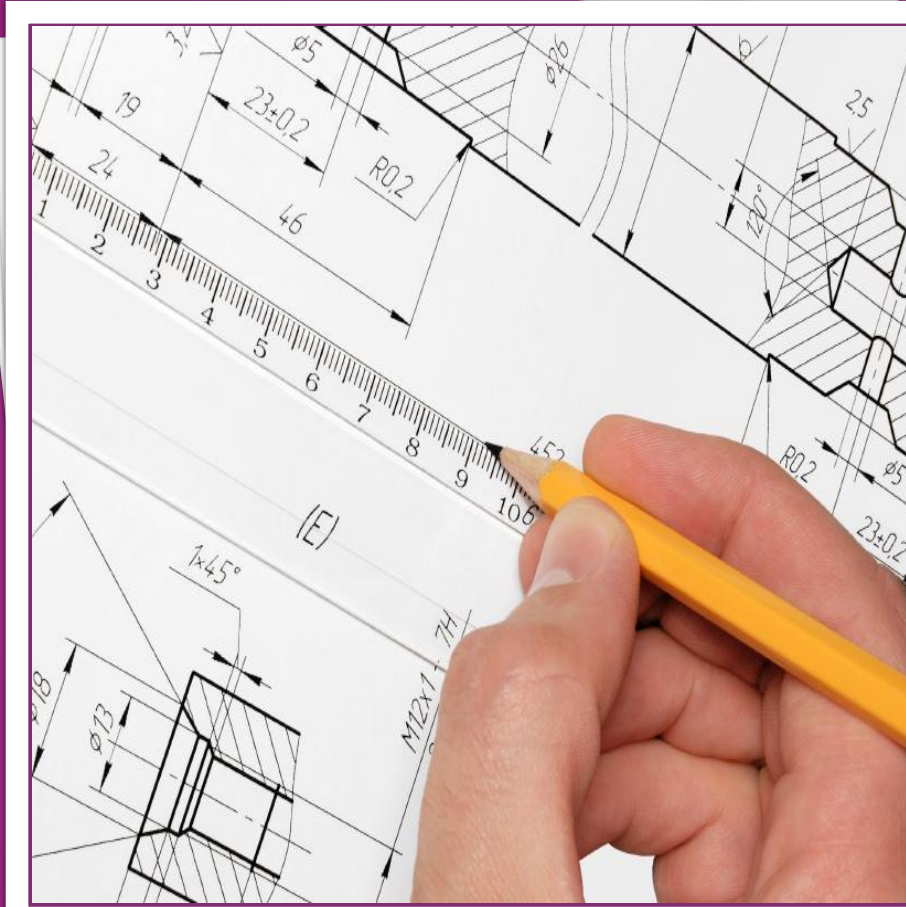
DESIGN FOR MULTIPLE PART ASSEMBLIES

- The thermoplastic processes generally operate with a cool mold, with the moldment remaining in the tool until the part is rigid enough to withstand the forces of ejection. If the part is ejected while it is too hot, it can be distorted and dimensional control lost.

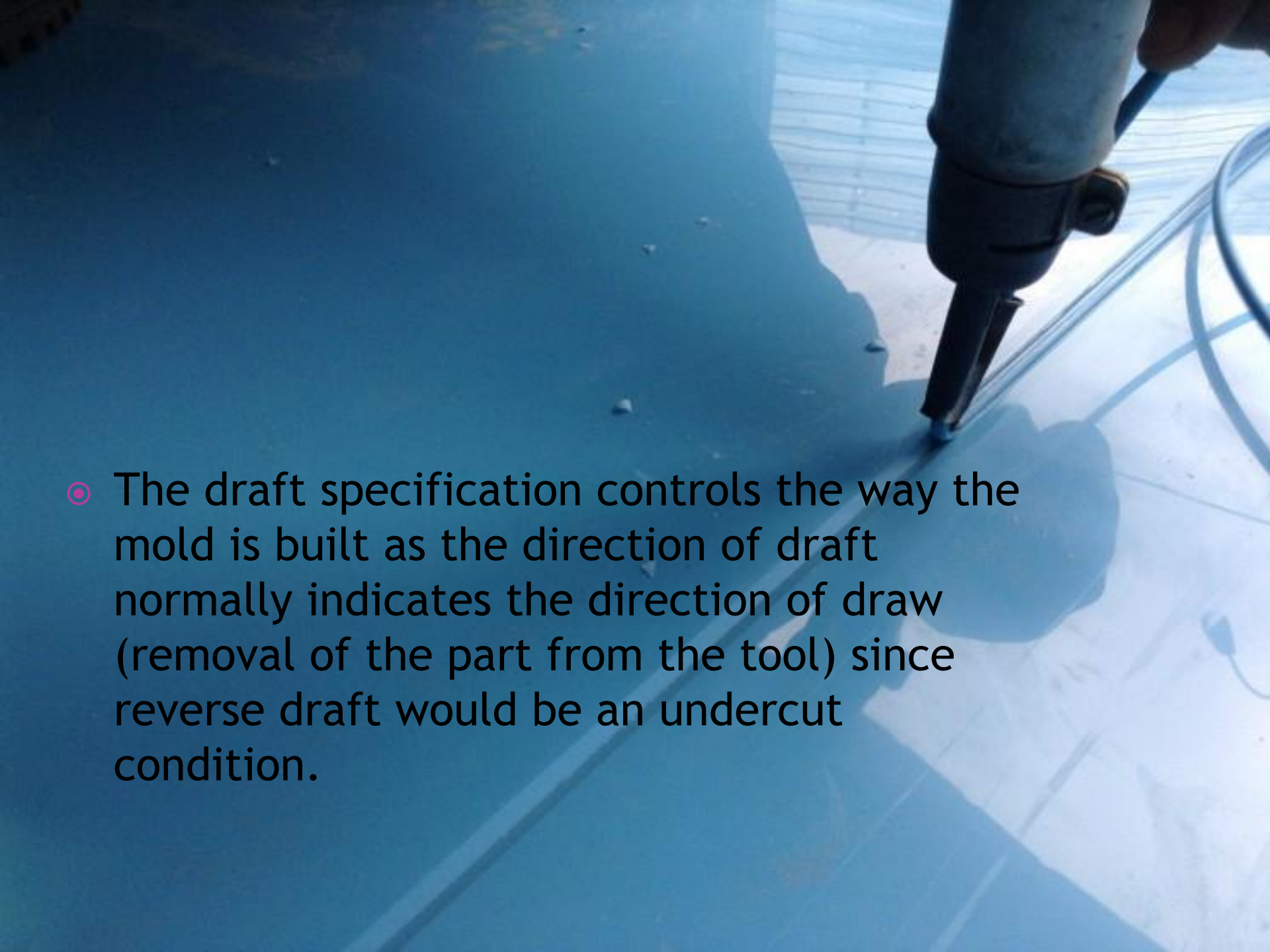


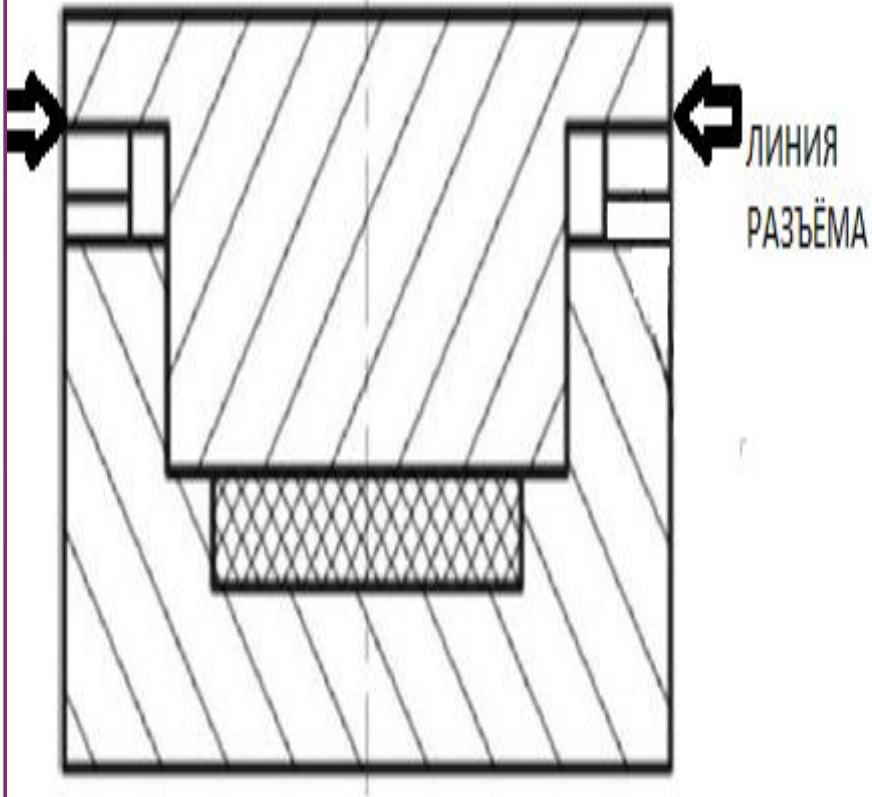
Deviations from drawing tolerances can be approved if they turn out to be excessively tight when the actual parts are available. When parts are accepted with deviations from the contract drawing, a written record should be retained and the drawing should be altered accordingly to reflect the newly approved tolerance. Regardless of how it is specified, the objective remains the same, namely, that the parts must fit together readily and stay together within acceptable parameters.

PLASTICS SPECIFICATIONS AND DRAFTING PRACTICES



The number or letter should be located in a place where it will not interfere with a fitment or the appearance of the part, each cavity must contain an identification number—location to be approved by engineering.

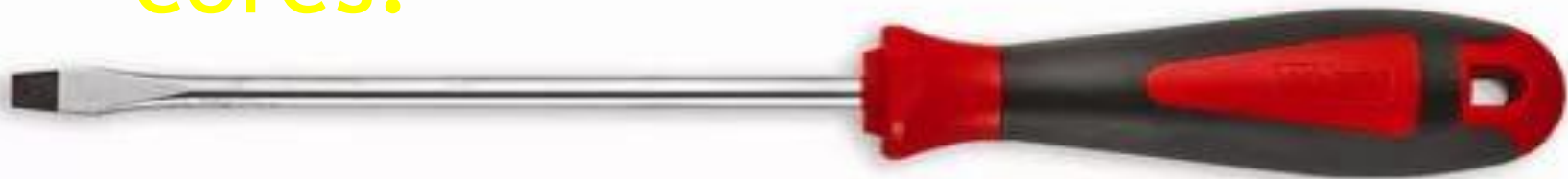
- 
- The draft specification controls the way the mold is built as the direction of draft normally indicates the direction of draw (removal of the part from the tool) since reverse draft would be an undercut condition.



The draft specification will also control the location of the parting line, which should be indicated.

EJECTOR LOCATIONS

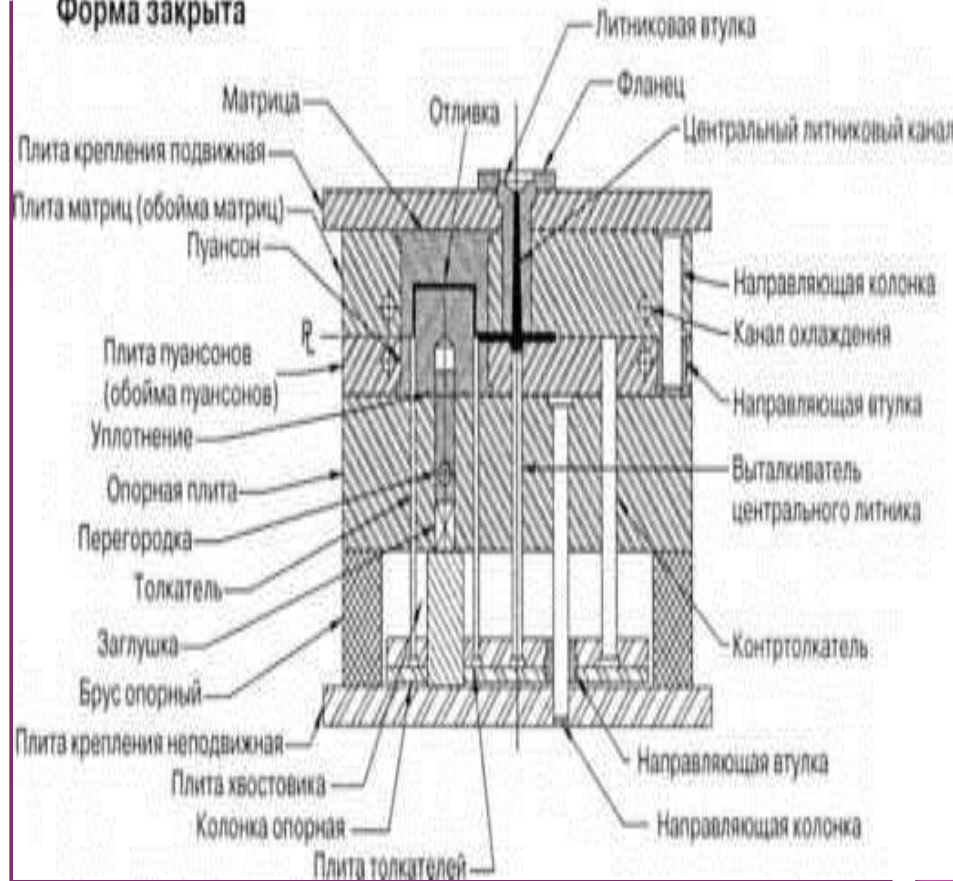
- Ejection devices for plastic parts can range from screwdrivers used to pry parts out of a hand mold to mechanized stripper plates and elaborate mechanisms which also retract collapsible cores.



The logo for HiVESIN, featuring a stylized gear icon and the company name in a bold, sans-serif font.

However, ejectors cost money and leave marks on the surface of the moldment. Therefore, there is a mold cost associated with a faster molding cycle.

Форма закрыта



**THE STRIPPER
PLATE IS A VARIETY
OF EJECTION
SYSTEM WHICH NEED
NOT LEAVE A MARK
ON THE PART.**



Parts from processes in which material flows in the mold nearly always have knit lines and these knit lines will be the weak points in the part.

- The material specification is, perhaps, the most critical of all the specifications. A material deviation can lead to a variety of problems in the molding of the part, its properties, and its performance, both short and long term.

| Формат | Зона | Лист | Обозначение | Наименование | Кол. | Примечание |
|----------------------------|-------------|----------|------------------|--------------------------------|---|------------|
| | | | | | | |
| <u>Документация</u> | | | | | | |
| А4 | | | TM.0001XX.100 СБ | Сборочный чертеж | 1 | |
| <u>Детали</u> | | | | | | |
| А4 | 1 | | TM.0001XX.101 | Планка | 1 | |
| А4 | 2 | | TM.0001XX.102 | Основание | 1 | |
| А4 | 3 | | TM.0001XX.103 | Планка | 1 | |
| А4 | 4 | | TM.0001XX.104 | Планка | 1 | |
| <u>Стандартные изделия</u> | | | | | | |
| | | 5 | | Болт М12 х 55 ГОСТ 7798-70 | 1 | |
| | | 6 | | Винт М10 х 25 ГОСТ 1491-80 | 1 | |
| | | 7 | | Гайка М12 ГОСТ 5915-70 | 2 | |
| | | 8 | | Шайба 12 ГОСТ 11371-78 | 2 | |
| | | 9 | | Шпилька М12 х 30 ГОСТ 22034-76 | 1 | |
| TM.0001XX.100 | | | | | | |
| Изм. | Лист | № док-м. | Подп. | Дата | Основание в сборе СП8УСЗ Группа 2301 | |
| Разраб. | Чертилкин | | | | | |
| Проб. | Проверялкин | | | | | |
| Н.контр. | | | | | | |
| Утв. | | | | | | |

The pressure for substitutions arises from market conditions. Material shortages and price increases force processors to seek means of relief. They will sometimes offer an “equivalent” material. Equivalent is, however, an ambiguous term when referring to plastics. It cannot mean precisely the same resin because resins are covered by patents and, therefore, each one is somewhat different than the others in its behavior and properties.



REGRIND LIMITATION

- Thermoplastics are capable of nearly 100% material utilization by regrinding sprues, runners, and reject parts and mixing that “regrind” in with virgin resin. However, the material suffers some degradation when it is raised to elevated temperatures.





The engineer should be alert to the fact that the use of regrind runs the risk of contamination of the resin from a variety of sources. If a contaminant will pose a significant risk for the application (medical product) or if the need for all of the physical properties is critical, it may be necessary to prohibit the use of regrind.

CONCLUSION

A pair of hands is shown from the top, cupping a large amount of small, white, translucent plastic pellets. The background is a vast field of these same pellets, creating a textured, repetitive pattern. The lighting is soft, highlighting the individual grains of the plastic.

- There are several aspects of plastics specifications and drawings (or files) which are particular to this family of materials and processes and which deal with realities which must be addressed.

TEXT OF PRESENTATION

- 1) The times we live in are often known as the “Computer Age.” It could also be referred to as the “Plastics Age,” as the production of plastics has exceeded that of steel (by volume) since 1979. In fact, the volume of plastics produced has more than doubled in the last 20 years. Nonetheless, most students who graduate from the major engineering universities are generally unprepared generally unprepared to design to design in plastics. Thus, it is left to the individual engineer to learn plastics engineering on his or her own, often by trial and error.
- 2) Unlike metals, the properties of most plastics vary considerably within normal operating temperatures. A particular acrylonitrile butadiene styrene (ABS) whose tensile strength is 5500 lb/in² at room temperature can drop to 2800 lb/in² at 125°F. Other properties are also affected. For example, brittleness increases as the temperature drops, etc.
- 3) What does this mean to the design engineer? Basically, it means there will be more work to do. It cannot be assumed that the product will survive the temperatures endured in cleaning, shipping, or storage unscathed.
- 4) Other exposures can cause problems with plastic components as well. Ultraviolet light causes or catalyzes chemical degradation in many resins. Plastics are vulnerable to attack from many chemicals, particularly in heavy concentrations. Some are even affected by water and there is one, polyvinyl acetate, that actually dissolves in water (for example, soap, packets).
- 5) That is not to suggest any skullduggery on the part of the test engineers; it is simply that the standard test sample and conditions are narrowly defined and likely to be significantly different from those to be endured by any specific product. The values obtained for most plastics will vary according to the process, gating, wall thickness, rate of loading, etc. It should be noted that there is some latitude within the test procedures themselves which can affect results. Most plastics engineers use the data sheets principally for the purposes of comparison in material selection.

TEXT OF PRESENTATION

- 6) Even if the material maintained its properties throughout the product's temperature range and the data was perfectly reliable, the product's performance could still vary. That is because the plastics processes are subject to tooling quality and process parameter variations.
- 7) Nonetheless, the fact that plastic parts can be successfully designed is attested to by the wide variety of products in the marketplace. It is clearly, however, more work to design in plastic and it is virtually impossible to perfectly predict the initial results. That is the reason prototypes are frequently made.
It is tempting to test a fabricated sample before constructing tooling.
- 8) In order to avoid unpleasant surprises which can cause a design to fail, it is necessary to know everything possible about the conditions which the product will be exposed to in its lifetime. Armed with that information, the plastics designer can determine if the design, material, process, and tooling are appropriate for the application.
- 9) A certain degree of risk is inherent in plastics design because the cost in time and resources is too great to permit the accumulation of enough information to eliminate that risk. Higher levels of risk are acceptable where tooling investment is low and where product failure results only in very low levels of property loss. As the cost of failure increases, more resources are devoted to risk reduction and greater safety factors are used. When product failure could result in serious injury or loss of life, exhaustive testing and greater safety factors are employed.
- 10) Process selection. Plastics product designers are primarily interested in the ability of a given process to produce the shape they require. Therefore, the processes have been grouped according to their ability to produce a given shape. The groupings are 1)thermoplastic open shapes; 2)thermoset open shapes; 3)hollow parts; 4)profiles; 5)ultra high strength.

TEXT OF PRESENTATION

- ◉ 11) Beyond the fundamental design requirements, cost becomes the most significant factor in selecting the optimum process for the application. Product cost has three interrelated components: part cost, labor cost, and tooling amortization. Labor is related to process selection because some plastics processes permit the combining of parts to eliminate labor cost.
- ◉ 12) As a broad statement, processes that require a higher initial investment in tooling produce parts at a lower cost. This is largely due to the fact that the reduced part cost is the product of faster molding cycles. Faster cycles require pressure on the plastic to reduce the time required to fill the mold cavity. The greater the pressure, the stronger the tooling and the more sophisticated the processing equipment must be. Both of these are factors which increase the initial investment.
- ◉ 13) The product design engineer is, therefore, keenly interested in the volume at which the additional investment would be justified by reduced part cost. It would simplify the decision making tremendously if it were possible to determine that point in terms of a given volume for each process. That might be feasible if all parts were identical in shape and size.
- ◉ 14) One may presume that the larger and/or more complex the part, the greater the investment will be. As the investment grows, the production volume must be greater in order to pay the difference with lower piece part costs within an acceptable time period.
- ◉ 15) Design for multiple part assemblies. The first step is to ensure that the parts fit together properly—not merely at room temperature, but at the temperature extremes of what the product may be expected to encounter. For example, a force fitment that works perfectly at room temperature may loosen at elevated temperatures or fracture at low temperatures.

TEXT OF PRESENTATION

- 16) That involves the determination of the fitments after the relationship of the parts to each Design of Plastic Products other has changed due to differences in the coefficient of linear thermal expansion. Thus, the establishment of acceptable dimensional limits, generally known as tolerances, for the fitment dimensions is of critical importance according to variations in process parameters.
- 17) The thermoplastic processes generally operate with a cool mold, with the moldment remaining in the tool until the part is rigid enough to withstand the forces of ejection. If the part is ejected while it is too hot, it can be distorted and dimensional control lost.
- 18) Deviations from drawing tolerances can be approved if they turn out to be excessively tight when the actual parts are available. When parts are accepted with deviations from the contract drawing, a written record should be retained and the drawing should be altered accordingly to reflect the newly approved tolerance. Regardless of how it is specified, the objective remains the same, namely, that the parts must fit together readily and stay together within acceptable parameters.
- 19) Plastics specifications and drafting practices. The number or letter should be located in a place where it will not interfere with a fitment or the appearance of the part, each cavity must contain an identification number—location to be approved by engineering.
- 20) The draft specification controls the way the mold is built as the direction of draft normally indicates the direction of draw (removal of the part from the tool) since reverse draft would be an undercut condition.
- 21) The draft specification will also control the location of the parting line, which should be indicated.
- 22) Ejector locations. Ejection devices for plastic parts can range from screwdrivers used to pry parts out of a hand mold to mechanized stripper plates and elaborate mechanisms which also retract collapsible cores.

TEXT OF PRESENTATION

- 23) However, ejectors cost money and leave marks on the surface of the moldment. Therefore, there is a mold cost associated with a faster molding cycle.
- 24) The stripper plate is a variety of ejection system which need not leave a mark on the part.
- 25) Parts from processes in which material flows in the mold nearly always have knit lines and these knit lines will be the weak points in the part.
- 26) The material specification is, perhaps, the most critical of all the specifications. A material deviation can lead to a variety of problems in the molding of the part, its properties, and its performance, both short and long term.
- 27) The pressure for substitutions arises from market conditions. Material shortages and price increases force processors to seek means of relief. They will sometimes offer an “equivalent” material. Equivalent is, however, an ambiguous term when referring to plastics. It cannot mean precisely the same resin because resins are covered by patents and, therefore, each one is somewhat different than the others in its behavior and properties.
- 28) Regrind limitation. Thermoplastics are capable of nearly 100% material utilization by regrinding sprues, runners, and reject parts and mixing that “regrind” in with virgin resin. However, the material suffers some degradation when it is raised to elevated temperatures.
- 29) The engineer should be alert to the fact that the use of regrind runs the risk of contamination of the resin from a variety of sources. If a contaminant will pose a significant risk for the application (medical product) or if the need for all of the physical properties is critical, it may be necessary to prohibit the use of regrind.
- 30) Conclusion. There are several aspects of plastics specifications and drawings (or files) which are particular to this family of materials and processes and which deal with realities which must be addressed.

QUESTIONS

- 1) Во сколько раз увеличился объем производства пластмассы?
- 2) В чем отличие металлов от пластмасс?
- 3) Что нельзя предполагать при переработке продукта?
- 4) Что вызывает ультрафиолетовый свет в полимерах?
- 5) Что используют большинство инженеров - специалистов при выборе материала?
- 6) Что требуется в производстве, когда нужна повышенная точность?
- 7) Для чего нужно знать всё об условиях, которые действуют на продукт?
- 8) Почему присуща определенная доля риска при конструировании изделия из пластмассы?
- 9) Как подразделяются процессы в соответствии с их способностью производить заданную форму?

QUESTIONS

- 10) Из каких трёх взаимосвязанных компонентов состоит стоимость продукта?
- 11) Почему в качестве общего описания, процессы требуют более высоких начальных вложений в оснастку для изготовления детали?
- 12) Что означает «сложный процесс» в качественных пластиковых окнах?
- 13) Как работают с термопластичными процессами?
- 14) Когда могут быть утверждены отклонения от чертежа и допуск?
- 15) Что делать, когда части приняты с отклонениями от чертежа?

QUESTIONS

- 16) Для чего нужно установление тождественности объекта при построении более чем одной полости?
- 17) Как должны располагаться цифры или буквы на чертеже?
- 18) Какие могут быть стенки в эскизе?
- 19) К чему может привести не правильный эскиз?
- 20) На что влияет способ построения пресс-формы в эскизе спецификации?
- 21) Что позволяет контролировать эскиз в чертеже детали?
- 22) Как происходит выталкивание устройств из пластиковых деталей?
- 23) Общая черта всех выталкивателей?

QUESTIONS

- 24) Что такое выталкивающая плита?
- 25) Почему допускается выталкивание в более нагретую часть?
- 26) Как можно определить хорошие сварные швы?
- 27) К чему может привести отклонения материала?
- 28) Что заставляет производителей искать материал дешевле?
- 29) На что влияет несоответствие в спецификации?
- 30) Дробленый материал повышает или понижает физические свойства материала?

KEYWORDS

- Plastic
- the mold
- Ejector
- Specification
- System
- Moldment
- Desing
- Temperature
- Products
- Engineer
- material

REFERENCES

- ◉ 1. Cadillac Plastic & Chemical Co., Troy, Mich.
- ◉ 2. Terry A. Richardson, "Machining and Finishing," Modern Industrial Plastics, Howard W. Sams & Co., New York, 1999. - P. 69.
- ◉ 3. John L. Hull, "Design and Processing of Plastic Parts," Handbook of Plastics Elastomers and Composites, 2d ed., Charles A. Harper, ed., McGraw-Hill, New York, 2001. - P.83.
- ◉ 4. J. O. Trauernicht, "Bonding and Joining, Weigh the Alternatives, Part 1, Solvent Cements, Thermal Welding," Plastics Technology, August 1999. - P.147.
- ◉ 5. "Engineer's Guide to Plastics," Materials Engineering, May 2002. - P. 369.
- ◉ 6. "Mechanical Fastening," Handbook of Plastics Joining, Plastics Design Library, Norwich, NY, 2001. - P.259.
- ◉ 7. "Joining of Composites," in A. Kelley, ed., Concise Encyclopedia of Composite Materials, The MIT Press, Cambridge, 1999. - P. 247-269.
- ◉ 8. D. K Rider, "Which Adhesives for Bonded Metal Assembly," Product Engineering, May 25, 2001. - P. 299-300.
- ◉ 9. "Surface Preparation of Plastics," in Adhesives and Sealants, vol. 3, Engineered Materials Handbook, H. F. Binson, ed., ASM International, Materials Park, Ohio, 2004. - P. 169.

A 3D rendering of a blue hexagonal lattice tunnel. The tunnel is formed by a series of interconnected hexagonal cells that recede into the distance, creating a strong sense of perspective. The walls of the tunnel are a deep blue color. In the center of the tunnel, there is a bright, glowing light source that illuminates the scene. Scattered throughout the tunnel are numerous glowing spheres. Some are a vibrant blue, while others are a bright green. The spheres vary in size and are positioned at different depths within the tunnel, some appearing to be on the walls and others floating in the center. The overall effect is a futuristic, high-tech environment with a strong sense of depth and perspective.

THANK YOU!