Fundamentals of Manufacturing Accuracy

Manufacturing can be defined as the transformation of raw materials into useful products through the use of the easiest and least-expensive methods. It is not enough, therefore, to process some raw materials and obtain the desired product.

It is, in fact, of major importance to achieve that goal through employing the easiest, fastest, and most efficient methods. If less efficient techniques are used, the production cost of the manufactured part will be high, and the part will not be as competitive as similar parts produced by other manufacturers. Also, the production time should be as short as possible to enable capturing a larger market share.

Modern industries can be classified in different ways. There include classification by process, classification by product, and classification based on the production volume and the diversity of products. The classification by process is exemplified by casting industries, stamping industries, and the like. When classifying by product, industries may belong to the automotive, aerospace, and electronics groups. The third method, i.e., classification based on production volume, identifies three main distinct types of production, mass, job shop, and moderate. Let us briefly discuss the features and characteristics of each type.

Mass production is characterized by the high production volume of the same (or very similar) parts for a prolonged period of time. An annual

production volume of less than 50 000 pieces cannot certainly be considered as mass production. As you may expect, the production volume is based upon an established or anticipated sales volume and is not directly affected by the daily or monthly orders. The typical example of mass-produced goods is automobiles.

Job-shop production is based on sales orders for a variety of small lots. Each lot may consist of 20 up to 200 or more similar parts, depending upon the customers` needs. It is obvious that this type of production is most suitable for subcontractors who produce varying components to supply various industries. The machines employed must be flexible to handle variations in the configuration of the ordered components ,which are usually frequent. Also, the employed personnel must be highly skilled in order to handle a variety of tasks, which differ for the different parts that are manufactured.

Moderate production is an intermediate phase between the job-shop and the mass-production types. The production volume ranges between 10 000 to 20 000 parts, and the machines employed are flexible and multipurpose. This type of production is gaining popularity in industry because of an increasing market demand for customized products.

A very important fact of the manufacturing science is that it is almost impossible to obtain the desired nominal dimension when processing a workpiece. This is actually caused by the inevitable, though very slight,

inaccuracies inherent in the machine tool as well as by various complicated factors like the elastic deformation and recovery of the workpiece and/or the fixture, temperature effects during processing, and sometimes the skill of the operator. Since it is very difficult to analyze and completely eliminate the effects of these factors, it is more feasible to establish a permissible degree of inaccuracy or a permissible deviation from the nominal dimension that would not affect the proper functioning of the manufactured part in a detrimental way. According to the ISO (International Standardization Organization) system, the nominal dimension is referred to as the basic size of the part. The deviations from the basic size to each side (i.e. , positive or negative) determine the high and the low limits, respectively, and the difference between those two limits of size is called the tolerance. The tolerance is an absolute value without a sign. As you may expect, the magnitude of the tolerance is dependent upon the basic size and is designated by an alphanumeric symbol called the grade. There are eighteen standard grades of tolerance in the ISO system, and the tolerances can be obtained from the formulas or the tables published by the ISO. It is obvious that smaller tolerances require the use of high-precision machine tools in manufacturing the parts and therefore increase production costs.

Before two components are assembled together, the relationship between the dimensions of the mating surfaces must be specified. In other

words, the location of the zero line to which deviations are referred must be established for each of the two mating surfaces. This actually determines the degree of tightness or freedom for relative motion between the mating surfaces. There are basically three types of fits, namely, clearance fit, transition fit, and interference fit. In all cases of clearance fit, the upper limit of the shaft is always smaller than the lower limit of the mating hole. This is not the case in interference fit, where the lower limit of the shaft is always larger than the upper limit of the hole. The transition fit, as the name suggests, is an intermediate fit. According to ISO, the internal enveloped part is always referred to as the shaft, whereas the surrounding surface is referred to as the hole. Accordingly, from the fits point of view, a key is referred to as the shaft and the keyway as the hole.

There are two ways for specifying and expressing the various types of fits, the shaft basis and the hole basis systems. The location of the tolerance zone with respect to the zero line is indicated by a letter, which is always capital for holes and lowercase for shafts, whereas the tolerance grade is indicated by a number, as previously explained. Therefore, a fit designation can be H7/h6, F6/g5, or any other similar form.

When the service life of an electric bulb is over, all you do is buy a new one and replace the bulb. This easy operation, which does not need a fitter or a technician, would not be possible without two main concepts,

interchangeability and standardization. Interchangeability means that identical parts must be interchangeable, i.e. , able to replace each other, whether during assembly or subsequent maintenance work; without the need for any fitting operations. As you can easily see, interchangeability is achieved by establishing a permissible tolerance, beyond which any further deviation from the nominal dimension of the part is not allowed.

影响加工精度的基本因素

制造业可以看作是通过使用最简便、最便宜的方法，把原材料转化为有用的产品的方法，但这显然还不够准确,它应该是通过对原材料的加工,进而获得所期望得到的产品。

实际上，通过采用最简单、最快捷和最有效的方法来达到目标是非常重要的。如果不能采用先进而有效的方法来加工，则产品的制造费用将增高，在与其他类似的产品制造商竞争时产品将会变得没有竞争力。 此外，为了获取更大的市场份额，产品生产的时间也应尽可能短。

现代工业可以使用很多不同的方法来分类，包括按加工方式分类，按产品的类型分类，按产品生产的数量和产品的差异性分类。按产品的加工方式来分类，在铸造行业及冲压行业中被广泛采用。而按产品的类型来分类的方法，则主要在汽车制造业、飞机制造业及电气业中采用。第三种方法,即按产品的生产量来分类的方法，确定了三种主要的生产方法：大批量生产、单件小批量生产、中批量生产。下面让我们来详细的讨论每种生产方式的特点。

大批量生产的特点是长时间的生产同一种（或者非常类似的）产品，如果一件产品的年生产量小于 50000 件则不能被视为大批量生产。正如你所能想到的，产品生产的数量是根据一个既定或预期的销售数量来决定的，而不是由一天或一个月的订单量来决定。一个典型的例子就是汽车的大规模生产。

单件小批量生产主要是按种类多而批量小的销售订单来生产，每个批量在 20 件到 200 件或者更多，主要决定于客户的需求。显而易见，这种类型的生产最适合分包商，生产不同的零件来供应各类不同的行业需求。所采用的机器必须具有足够的柔性，以适应按订单生产的零件的外形变化，而这种变化是经常发生的。另外，操作机器的工人也必须掌握比较高的技术水平，这样才能成功的完成各种不同的任务，加工不同的零件。

中批量生产是介于大批量生产和单件小批量生产之间的一种类型，生产量介于 10000 至 20000 件之间，而采用的机器也必须很灵活和多功能化。由于按客户需求制造的产品的市场日益增长，这类类型的应用越来越多。

在制造科学中，有一个非常重要的事实是：加工一个工件时要想获得理想的名义尺寸几乎是不可能的。其实，虽然误差可能非常的小，但这是不可避免的，

因为很多复杂的因素造成机器上的刀具存在有固有的误差。比如工件的弹性变形及其回弹，又或者工件的装夹、加工过程中温度的影响，有时还包括操作人员的操作技能。由于准确的分析并完全消除这些因素的影响是非常困难的，于是在名义尺寸之上建立一个允许的误差或允许的偏差范围更为可行，而这也不会影响工件的正常运作。按照 ISO (国际标准化组织)体系，公称尺寸被称为零件的基本尺寸，从基本尺寸向每一侧的偏差（正或负）分别决定了上限和下限，而二者之间的差值称为公差。公差是一个没有标志的绝对值，正如你可以想到的，公差的大小决定于基本尺寸的大小，而由一个指定的字母数字符号来表示，称为等级。在 ISO 质量管理体系中，一共设有 18 个标准等级，公差可从公式算出或从 ISO 出版的表中查出来。显然，公差较小的零件需要利用高精密机床来制造，而由此会导致产品成本的增加。

在两个零件组装在一起之前，尺寸的配合关系必须指定。换句话说，必须在两个尺寸之间指定零线的位置。这其实是确定两个物体配合的紧密或能自由运动的范围。基本上可以分为三种配合，即间隙配合，过渡配合，过盈配合。在所有的间隙配合中，轴的上极限尺寸常常比与其配合的孔的下极限尺寸还小；这与过盈配合不同，在过盈配合中轴的下极限尺寸通常比孔的上极限尺寸大；过渡配合，顾名思义,是一个中级的配合。按国际标准化组织的规定，被包围在里面的部分常称之为轴，而包围的表面则称之为孔。因此，从配合的观点来说，键被称为轴，键槽被称为孔。

有两种方式来指定和表示各种不同的配合，基轴制和基孔制。公差带相对于基准线的位置是用一个字母来表示的，总是用大写字母表示孔，用小写字母表示轴；而公差等级则如前所述用数字表示。正如先前解释的， H7/h6，F6/g5 都是正确的表示方式，其他类似的形式也是对的。

当一个电气部件的使用寿命结束时，所有你能做的就是去买一个新的来代替它。这是一件非常容易的事情，不需要任何钳工或技术员，然而如果没有两个概念：互换性和标准化，这一切将不可能。互换性意味着在相同的零件之间必须能够进行互换。无论是在装配时还是在其后的维修中，这些零件都可以互相取代而不需任何修配工作。你不难看出,互换性是通过建立一个允许的公差来达到目的的，然而任何超过范围的基本尺寸的偏差都是不允许的。