Types of fits

Design for HP MJF: Union joints design

Introduction

HP Multi Jet Fusion technology allows users to print mating parts to create functional assemblies. When designing mating parts with the suitable tolerance and type of fit, it is important to save time in post-processing and assembly operations.

Fits are used to establish tolerances between inner and outer features of bearings, bushings, shafts, or drilled holes, and are often represented as a shaft and a hole, although they include other parts that are not only cylindrical.

There are two types of fits based on the allowable limits for shaft and hole size:

Clearance fit

A clearance fit leaves a space or clearance between mating parts: The hole diameter is larger than the shaft diameter. The shaft can slide and/or rotate in the hole when assembled, requiring no force.

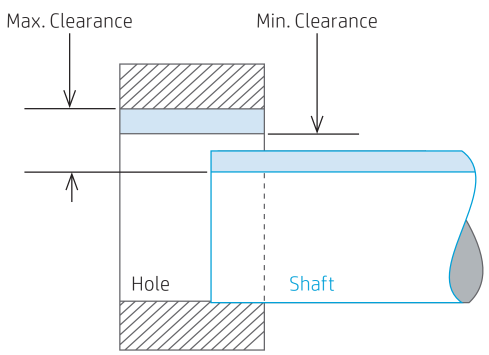

Figure 1: Clearance fit

In this type of fit, the maximum clearance is the difference between the maximum size of the hole and the minimum size of the shaft, while the minimum clearance is the difference between the minimum size of the hole and the maximum size of the shaft.

Interference fit

In an interference fit the hole diameter is smaller than the shaft diameter. This type of fit does not allow relative motion between mating parts, providing a strong connection and requiring strong force in assembly and disassembly.

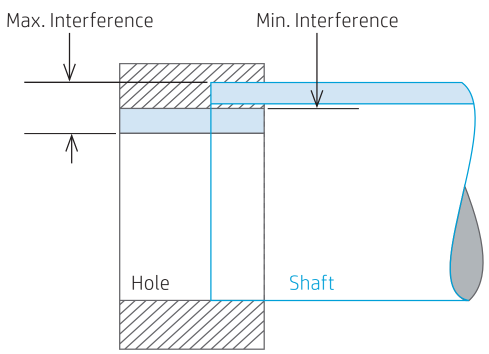

Figure 2: Interference fit

In this type of fit the maximum interference is the difference between the maximum size of the shaft and the minimum size of the hole, while the minimum interference is the difference between the minimum size of the shaft and the maximum size of the hole.

Design guidelines

Depending on how the mating parts must fit to achieve the assembly's functional needs, the required tolerances will be tighter or wider, which will determine whether additional post-processes, such as machining, are required to achieve suitable accuracy.

Standard fits

There are international standards in the metric system—ISO 286 and ANSI B4.2—and the imperial system—ANSI B4.1—that define the allowable tolerance limits that should be used depending on the type of fit required.

It is common to use the International Tolerance Grades defined in ISO 286, which provide a reference for typical manufacturing process capability in terms of tolerance accuracy, as shown in the following table:

														Plastic injection				
	For Measuring Tools									For Material								
IT Grades	01	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
							For Fits							For Large Manufacturing Tolerances				
															HP MJF			

Table 1: IT grades

Each IT grade establishes the allowable tolerance limits for a given dimension. As shown in the following table, a smaller IT grade provides tighter tolerances:

Standard tolerance grades	Values of standard tolerance (mm)								Nominal size (mm)
	from: 1 to: 3	3 6	6 10	10 18	18 30	30 50	50 80	80 120	
1	0,0015	0,0015	0,0015	0,0015	0,0015	0,002	0,002	0,003	Measuring tools
2	0,002	0,002	0,002	0,002	0,002	0,003	0,003	0,004	
3	0,003	0,003	0,003	0,003	0,004	0,004	0,005	0,006	
4	0,004	0,004	0,004	0,005	0,006	0,007	0,008	0,010	
5	0,005	0,005	0,006	0,008	0,009	0,011	0,013	0,015	Engineering fits, bearings, machining processes (grinding, turning)
6	0,007	0,008	0,009	0,011	0,013	0,016	0,019	0,022	
7	0,009	0,012	0,015	0,018	0,021	0,025	0,030	0,035	
8	0,014	0,018	0,022	0,027	0,033	0,039	0,046	0,054	
9	0,025	0,030	0,036	0,043	0,052	0,062	0,074	0,087	
10	0,040	0,048	0,058	0,070	0,084	0,100	0,120	0,140	
11	0,060	0,075	0,090	0,110	0,130	0,160	0,190	0,220	
12	0,090	0,120	0,150	0,180	0,210	0,250	0,300	0,350	Large manufacturing, die casting, stamping, sand casting
13	0,140	0,180	0,220	0,270	0,330	0,390	0,460	0,540	
14	0,250	0,300	0,360	0,430	0,520	0,620	0,740	0,870	
15	0,400	0,480	0,580	0,700	0,840	1,000	1,200	1,400	
16	0,600	0,750	0,900	1,100	1,300	1,600	1,900	2,200	
17	0,900	1,200	1,500	1,800	2,100	2,500	3,000	3,500	
18	1,400	1,800	2,200	2,700	3,300	3,900	4,600	5,400	

Table 2: Standard tolerance grades

Usually, the most common types of fits require very tight tolerances that cannot be achieved by designing and printing the part directly, and additional post-processes, such as machining, are required to achieve suitable accuracy.

Thus, there are some recommendations for designing a part that will need to be machined after printing to achieve the tight tolerances required. These recommendations include accurate holes and bearing housings.

Accurate holes

Depending on how the hole is machined, a pre-hole or pilot hole can be designed into the part to guide the drill bit to the appropriated location. If the part is machined directly with a drill bit size equal to the final required hole diameter, it is recommended to machine the part without a designed pre-hole, letting the CNC Machine create the pre-hole to ensure proper positioning of the drill.

When it is necessary to machine a hole with a larger diameter than the available drill head, it will need to be machined by interpolating. In this case, a pre-hole or pilot hole can be designed into the part, where the required diameter must be at least 1 mm smaller than the final hole diameter.

Bearing housing

In applications where fitting a bearing is required, it is recommended to machine it, interpolating with a smaller drill and then adjusting it to the required tolerance. Like the case mentioned above, a pre-hole can be designed to save material, where the required diameter must be at least 1 mm smaller than the final diameter to ensure a proper finish.

Figure 3: Bearings inserted into an HP MJF part

Customized fits

When designing mating parts to create functional assemblies with a non-required standard fit, it is recommended to consider the following design guidelines:

- To print a clearance fit: When inserting a metal shaft into an HP MJF part hole, the minimum clearance must be as follows:

    Clearance between mating parts >maximum size of the metal shaft + minimum size of the HP MJF part hole

- To print an interference fit: When inserting a metal pin into an HP MJF part hole, the minimum interference must be as follows:

    Interference between mating parts >minimum size of metal pin+ maximum size of the HP MJF part hole

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