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Segments Assembly Process Analysis and Quality Control Measures

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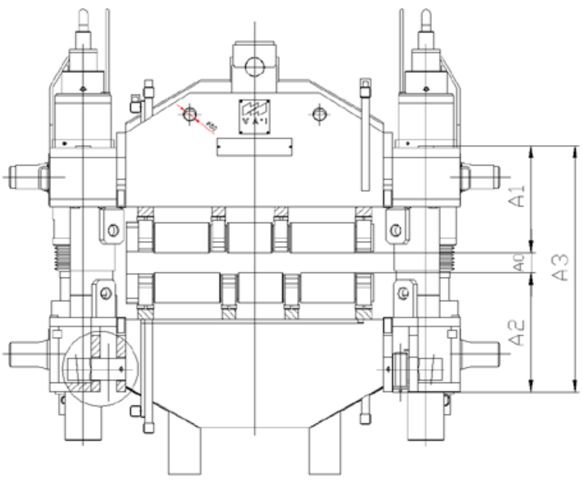
Abstract. In continuous casting, continuous casting lines constitute a single continuous casting machine is generally referred segment, In general, it is divided into actuate segment (or curved section), straightening section, horizontal section and so on. According to different billet can be divided into plate segments, billet segments and round billet segments. The most common is the production of plate and billet segments, segments that require high assembly quality, both inside and outside the arc to adjust the degree of opening height the frame and the roller arc height high demand, In this paper, analysis billet segments assembly processes and discussion of its assembly quality control measures.

Introduction

Segments having a mass production situation, the device structure is complex, the opening degree of precision and quality point arc, big impact on the quality of the slab. Size on the opening height the A (A_0) has two aspects, one curved arc size A_1, A_2, and second, to adjust the opening size of A_3. For the assembly precision, high efficiency, the choice of method of assembling interchangeable assembly method. To this end find out the impact of the relevant dimensions of assembly precision, the establishment of assembly dimension chain, determine the composition of limit deviations ring. Finally, the various components of the assembly dimension chain ring with a deviation of size parts processing chain analysis and control.

Effect of the Opening Height the A (A_0) Size are the A_1, A_2, A_3, Analysis and Calculation of Tolerances and Limit Deviations of these Dimension.

The opening height precision rolled plate according to the technical requirements for the A=230±0.3mm high precision, as shown in Figure1, Dimensions A_1, A_2, A_3 for the composition ring, choose completely interchangeable assembly method. In both ends of the roll Case No.1, 7, A_1=759.48mm, A_2=765.41mm, A_3=1753mm. Figure. 2 shows the assembly dimension chain. Where A_0 is for the closed loop, A_1 and A_2 are for minus loop, A_3 is for plus loop.



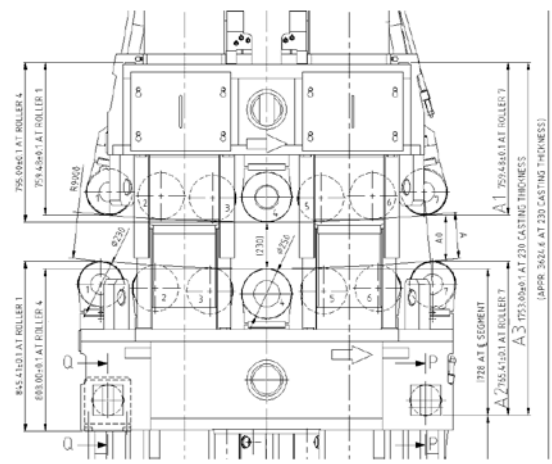


Fig.1 Segment General Assembly Drawing

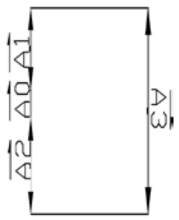


Fig.2 Segments opening height assembly dimension chain

Closed Loop Size. The closed loop size is

$$A_0=A_3(A_1+A_2)=1753-(759.48+765.41)=228.11\text{mm}$$

Closed Loop Tolerance. The closed loop tolerance is

$$T_0=+0.3-(-0.3)=0.6\text{mm}.$$

Each Consisting of a Ring Tolerance (tolerance average and standard tolerances of the constituent rings is given). The average composition of each ring tolerance is

$$T_{avA}=T_0/m(m\text{−Ring Qyt.})=0.6/3=0.2\text{mm}$$

Due to A_1, A_2 segment in the same size range, according to standard tolerances T_{avA} close to IT9, according to IT9 the composition of the ring A_1, A_2 tolerance for $T_1=T_2=0.2$mm, then

$$T_3=T_0-T_1-T_2=0.6-0.2-0.2=0.2\text{mm}.$$

Each Composition Ring Limit Deviation. Limit deviation due to the composition of the ring into the body unknown direction, so base on the "symmetrical deviation" configuration principle, take $A_1=759.48\pm0.1$mm; $A_2=765.41\pm0.1$mm; $A_3=1753\pm0.1$mm.

Limit the Size of the Accounting Closed ring.

$$A_{0max}=1753.1-759.38-765.31=228.41\text{mm}$$

$$A_{0min}=1752.9-759.58-765.51=227.81\text{mm}$$

Then $A_0=228.11\pm0.3$mm. Accounts show that the closed loop size to meet the requirements, so the A_1, A_2, A_3 take as: $A_1=759.48\pm0.1$mm; $A_2=765.41\pm0.1$mm; $A_3=1753\pm0.1$mm.

Above value of A_1, A_2, A_3 meet to drawings, as long as their manufacturing, we can guarantee complete with mounted for qualified products.

Above Frame Assembly, for Example, Analyze the Effect of Each of A_1 Size Tolerances and Limits

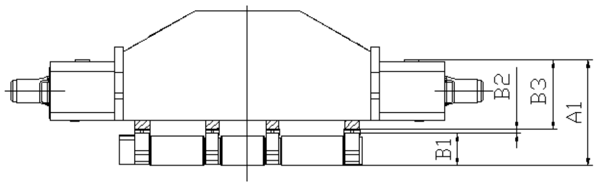


Figure.3 Inner arc frame in segement

A_1 is on the roll surface from within the framework of the arc from the plane, which determines the size of the arc-shaped roller surface precision. According to the above analysis, A_1 size requirements as $A_1=759.48\pm0.1$mm, A_1 is associated with the size of B_1, B_2, B_3, shown in Figure 3.

B_1 for the roller assembly size, which has its own size chain; B_2 for the middle plate and adjust the pad size; B_3 for the inner frame size. Analysis calculated for A_1 of three steps: ①Analysis calculated for B_1, B_2, B_3 of the size tolerances and limits; ②B_1 determined after calculation and B_1-related dimensional tolerances and limit deviations. ③ Comprehensive analysis of a given A_1 in each size tolerances and limits.

Analysis Calculated B_1, Tolerances and Limits B_2, B_3. By calculation, if the components are completely interchangeable ring by assembly method selected, B_1 tolerance of T=0.04mm, too strict, difficult to manufacture. So here to choose a statistical analysis to calculate interchange assembly, because in a stable process system performed when mass production and mass production, part size extremes appear unlikely. Now still ends roller Case No.1 and No.7: $B_1=(125\times\text{COS}10°+230/2)=238.1$mm, $B_2=(33\times\text{COS}10°)=32.5$mm, $B_3=488.88$mm (within the framework of the arc processing size), after assembly to ensure that the size of $a_1=759.48\pm0.1$mm. Figure 4 shows the assembly dimension chain.

A_1 is a closed loop, B_1, B_2, B_3 as plus ring, without minus ring.

The size of a closed loop is

$$A_1=238.1+32.5+488.88=759.48\text{mm}$$

The closed loop tolerance is

$$T_0= + 0.1-(-0.1)=0.2\text{mm}$$

The average square tolerance of each component ring is

$$T_{avgA} = T_0 / \sqrt{m} = 0.2 / \sqrt{3} = 0.115$$

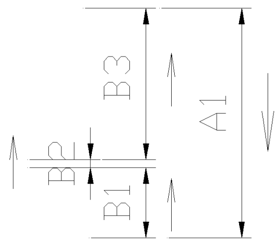


Fig.4 No.1and7 roller assembly dimension chain

Due to B_2 is small size and good processing, so define it to coordinate ring; according to B_1, B_3 size segment, according to the standard tolerance, B_1 by IT 9, B_3 by IT8, tolerance respectively T_1=0.115mm, T_3=0.97mm, then

$$T_2 = \sqrt{T_0^2 - T_1^2 - T_3^2} = \sqrt{0.22 - 0.1152 - 0.0972} = 0.132\ \text{mm}$$

Easy processing due to B_2, B_3 size is determined by the frame processing, frame and difficult process, so the tolerance reassigned as: T_1 = 0. 1 4 mm, T_2 = 0. 06 mm, T_3 = 0.10mm.

Then

$$T_0 = \sqrt{T_1^2 - T_2^2 - T_3^2} = \sqrt{0.412 - 0.062 - 0.102} = 0.182\text{mm.}$$

This value is less than T_0 = 0.2mm.

The limit deviation of each component ring is as follows. B_1 for the roller assembly dimensions. Tentatively define B_1=238.1±0.07mm. B_3 is frame sizes, finished products, one end of the size of the reference plane, and the other end of the size of the notch surface, into the direction of the body composed of the ring limit deviation is unknown, by "symmetrical bias" configuration principle, take B_3=488.88±0.05mm. B_2 for the plate size, is the coordination ring, the final set. Due to the closed loop center deviation $\varDelta_0=\varDelta_1+\varDelta_2+\varDelta_3$, so$\varDelta_2=\varDelta_0-\varDelta_1-\varDelta_3$.

$$\varDelta_0=[0.1+(-0.1)]/2=0\text{mm}$$
$$\varDelta_1=[0.07+(-0.07)]/2=0\text{mm}$$
$$\varDelta_3=[0.05+(-0.05)]/2=0\text{mm}$$
$$\varDelta_2=0-0-0=0\text{mm}$$

Upper deviation of B_2 is

$$ES_2=\varDelta_2+T_2/2=0+0.06/2=0.03$$

Below deviation of B_2 is

$$EI_2=\varDelta_2- T_2/2=0-0.06/2=-0.03$$

Take B_2=32.5±0.03mm, and take B_1=238.1±0.07mm; B_2=32.5$^{+}_{-}$0.03mm; B_3=488.88±0.05mm.

Accounting closed loop limit deviation is as follows.

$$\varDelta_0=\varDelta_1+\varDelta_2+\varDelta_3=0+0+0=0\text{mm},\quad T_0 = \sqrt{T_1^2 - T_2^2 - T_3^2} = \sqrt{0.412 - 0.062 - 0.102} = 0.182\text{mm.}$$

So $ES_0=\varDelta_0+T_0/2$=0+0.182/2=0.091mm,$EI_0=\varDelta_0-T_0/2$=0−0.182/2=−0.091mm, A_1=759.48±0.091, meet to A_1=759.48±0.1mm.

According to accounting results, B_1, B_2, B_3 take values: B_1=238.1±0.07mm; B_2=32.5±0.03mm； B_3=488.88±0.05mm.

From the results, B_1, B_2, B_3 sizes, only B_3 meet to drawings, B_1, B_2 and the size of the drawings are not consistent, which shows, according to drawing processing and can’t meet the production and quality of production requirements, according to the size of the manufacturing analysis, can guarantee to "pick up the parts on the equipment, ensure Bahrain are qualified" requirements, in order to achieve production goals.

Dimensional Tolerances and Limit Deviations Analysis Calculated for B_1 Influential Constituent Rings. B_1=238.1 after dimensions of the roller assembly, mounted on the portion 7 # free rollers. Here to separate out a ϕ250 drive roller assembly, its size is 260B_1. The following analysis of size 260 to size instead of 238.1. Figure 5 shows the roller assembly two points, one is the lower half of the roller sleeve, bearing, spindle, bearing, size 1 at B=135; the second is the upper half of the mandrel and sleeve, size B_{1on}=250/2=125. Free roller tolerance and the same drive roller, the process of several negligible analysis: the bearing only consider the inner and outer ring size tolerance, internal radial tolerances, etc.; spindle and the roller sleeve of the key parts are not accounted for only consider the mandrel diameter and tolerance of roller inner diameter.

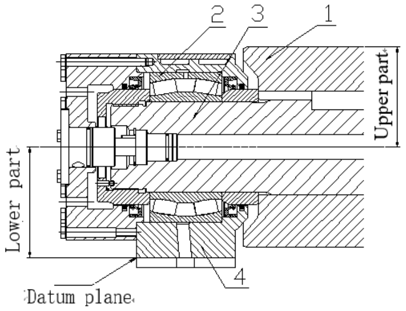


Figure.5 Φ250 drive roller assembly

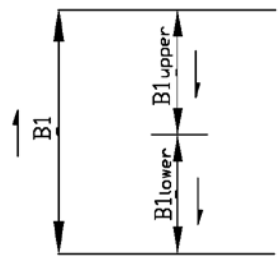


Figure.6 Assembly Dimension Chain

(1) First, B_1=260±0.07mm of tolerance exploded onto the lower half of the roller assembly. The allowable dimensional tolerances and limit deviations for the upper and lower roller assemblies are calculated and analyzed.

1- roller sleeve: the inner diameter of Φ=129H7$\binom{+0.040}{0}$, the outer diameter Φ= $250^{+0.1}_{-0.1}$.

2- bearings: inner φ=$110^{0}_{-0.02}$, outer φ=$180^{0}_{-0.025}$.

3- mandrel: a large-diameter φ=129h6$\binom{0}{-0.025}$, the small diameter φ=110f7$\binom{-0.036}{-0.071}$.

4- bearing: bore φ=180H7$\binom{+0.04}{0}$, the base surface to the hole center distance L=135.

According B1 tolerance value, still choose to exchange statistical analysis to calculate the assembly, after assembly to ensure that the size of B_1=260±0.07mm. Assembly size chain as shown in Figure 6.

$B_1$is a closed loop, the B_1, $B_1$is under increasing ring, without reducing ring.

Closed loop on the size is

$$B_1=B_1+B_{1under}=135+250/2=260 \text{ mm}$$

The closed loop tolerance is

$$T_0=+0.07-(-0.07)=0.14 \text{ mm}$$

The average square tolerance of each component ring is

$$T_{avgA}=T_0/\sqrt{m}=0.14/\sqrt{2}=0.099$$

According to the B_1, B_1 lower size segment, according to standard tolerances take *IT9*, tolerance of T_1=T_2=0.10 mm . Because under B1 chain size small, so the tolerance reassigned as:T_1=0.10 mm, T_2 = 0.09mm.

Then $T_0=\sqrt{T_1^2+T_2^2}=\sqrt{0.10^2+0.09^2}=0.135$mm. This value is less than T_0=0.14mm.

Constituent limit deviation ring is as following. The lower half of the roller sleeve on B_1, bearings, spindle, bearing assembly dimension, tentatively scheduled for next B_1=135±0.05mm.

Under B_1 for the upper half of the mandrel and sleeve assembly size, tentatively scheduled for the B_1=125 ± 0.045 mm.

Calculate the limit deviation of closed loop is

Δ_0=Δ_1+Δ_2=[0.05+(−0.05)]/2+[0.045+(−0.045)]/2=0mm,

$T_0=\sqrt{T_1^2+T_2^2}=\sqrt{0.10^2+0.09^2}=0.135$mm, ES_0=Δ_0+T_0/2=0+0.135/2=0.07mm, EI_0=Δ_0−T_0/2=0−0.135/2=−0.07mm.It can be seen B_1=260±0.07 comply with B_1=260±0.07mm requirements. According to the accounting result, the B_1, B_1 lower value of:B_{1upper} =135±0.05mm; B_{1below} =125±0.045mm.

(2) Under the B_1=135±0.05mm decomposed into the lower half of the roller assembly, B_1 lower tolerance is allowed under half of the roller assembly gap, shown in Figure 7. The lower half of the roller is equipped with two gap size, a processing size. Two gap sizes: small diameter mandrel $\varphi=110^{-0.036}_{-0.071}$ with the gap and the bearing inner ring $\varphi=110^{0}_{-0.02}$,the bearing bore $\varphi=180^{0}_{-0.025}$ and the bearing outer ring $\varphi=180^{0}_{-0.025}$ with gap; processing size have bearing center height 135±0.1. By figure 7 calculate the size of the gap and processing resulting assembly clearance under B_1 compared with the size of the allowable gap.

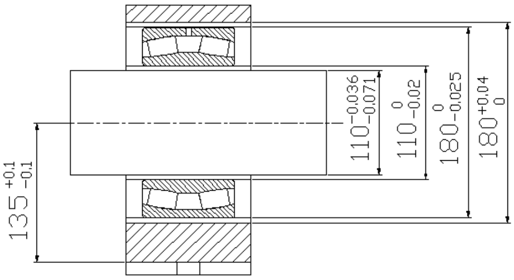


Figure.7 Lower half roller assembly clearance

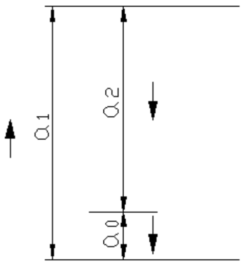


Figure.8 lower half of the roller assembly dimension chain

①The mandrel path $\varphi=110^{-0.036}_{-0.071}$ with the bearing inner ring$\varphi=110^{0}_{-0.02}$ tolerance fit analysis, the formation of dimensional chain Figure 8, closed loop $a_0=a_1-a_2$, $a_{max}=0/2-(-0.071/2)=0.0355$, $a_{min}=-0.02/2-(-0.036/2)=0.008$, $a_0=0^{+0.0355}_{+0.008}$ (assembly clearance).

②Bearing inner bore$\varphi=180^{+0.04}_{0}$ and the bearing outer ring $\varphi=180^{0}_{-0.025}$ with tolerance analysis, the formation of the size of the chain as shown in Figure 9: Closed loop $a_{01}=a_3-a_4$, $a_{max}=0.04/2-(-0.025/2)=0.0325$, $a_{min}=0/2-0/2=0$, $a_{01}=0^{+0.0325}_{0}$ (assembly clearance).

③Bore center plane to the distance L= 135±0.1 tolerance fit analysis. Dimension Chain see Figure 10:

Closed loop $a_{02}=a_5-(a_0+a_{01})$, $a_{max}=0.1-(0.008+0)=0.092$, $a_{min}=-0.1-(0.0355+0.0325)=-0.168$, $a_{02}=0^{+0.092}_{-0.168}$ (assembly tolerance value).

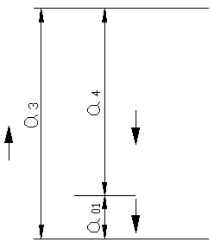


Figure.9 the bearing outer ring assembly size chain

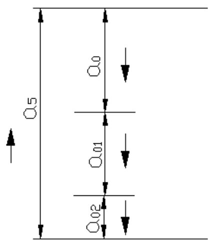
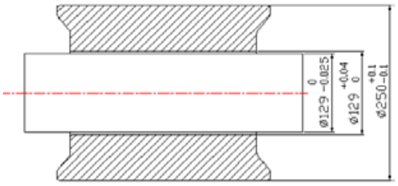


Figure.10 Base into the hole assembly dimension chain

Through the above analysis, $a_{02}=0^{+0.092}_{-0.168}$ (assembly tolerance value) B_{1below} = 135 ± 0.05 mm mm does not match, due to ①, ② item change space is small, so only key to adjust ③ So a_{02} and B_1 under the anastomosis. By calculation, $L=135^{+0.1}_{-0.1}$ take $L=135^{+0.06}_{+0.02}$, then $a_{max}=0.06-(0.008+0)=0.052$, $a_{min}=0.02-(0.0355+0.0325)=-0.048$, $a_{02}=0^{+0.052}_{-0.048}$ (assembly tolerance values) B_{1below} =135±0.05 mm for meet, after adjustments ,take B1below=$135^{+0.052}_{-0.048}$ mm.

(3)Decomposed B_1 upper=125±0.045mm into the upper half of the roller assembly, the B_1 upper tolerance is the upper half of the roller assembly to allow clearance shown in Figure 11. The upper half of the roller is equipped with two gap size: large diameter mandrel $\varphi=129^{0}_{-0.025}$ and the inner diameter of the roller sleeve $\varphi=129^{+0.04}_{0}$ with the gap, the spindle center to the outer diameter of the roller sleeve φ=250±0.1 with the gap. 11calculated for each by gap resulting assembly gap compared with the B_1 size allowable gap.



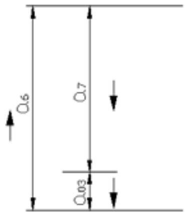


Figure.11 allow the upper half of the roller assembly gap   Figure.12 large diameter mandrel assembly dimension chain

①For large diameter mandrel $\Phi=129^{0}_{-0.025}$ and the roller sleeve inner diameter $\Phi=129^{+0.04}_{0}$ tolerance fit analysis, the formation of dimensional chain Figure 12: Closed loop $a_{03}=a_6-a_7$, a_{max}=0.04/2−(−0.025/2)=0.0325, a_{min}=0/2−(0/2)=0 , a_{03}=0+0.03250 (assembly tolerance value).

②Spindle center to the outer diameter of the roller sleeve Φ=250±0.1 tolerance fit analysis, the formation of dimensional chain Figure 13: Closed loop $a_{04}=a_8-a_{03}$, a_{max}=0.1/2−0=0.05, a_{min}=–0.1/2−(0.0325)=−0.0825, $a_{04}=0^{+0.05}_{-0.0825}$ (assembly clearance). Through the above analysis, $a_{04}=0^{+0.05}_{-0.0825}$ (Assembly tolerance value) And on B_1=125±0.045mm do not coincide, because ① Term changes very little space, so only key to make the adjustment ② a_{04} and B_1 match. By calculation, the outer diameter of the roller sleeve by the Φ=250±0.1 take $\Phi=250^{+0.09}_{-0.025}$ then a_{max}=0.09/2−0=0.045, a_{min}=−0.025/2−(0.0325)=−0.045, $a_{04}=0^{+0.045}_{-0.045}$ (assembly tolerances) and B_1. on = 125±0.045mm fit, take the B_1 at cost: the B_1=125±0.045m .

(4)Take the set $B_1=135^{+0.052}_{-0.048}$ mm, B_1=125±0.045mm, closed loop B_1 accounting limit deviation is

$$\Delta_0=\Delta_1+\Delta_2=[0.052+(-0.048)]/2+[0.045+(-0.045)]/2=0.002\text{mm},$$

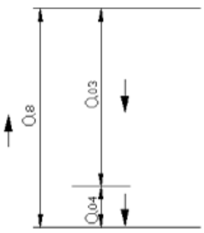
$$T_0=\sqrt{T_1^2+T_2^2}=\sqrt{0.10^2+0.09^2}=0.135\,\text{mm},$$

So

$$ES_0=\Delta_0+T_0/2=0.002+0.135/2=0.07\text{mm}$$

$$EI_0=\Delta_0-T_0/2=0.002-0.135/2=-0.07\text{mm}$$

Seen B_1=260±0.07 in line with B_1=260±0.07mm requirements.



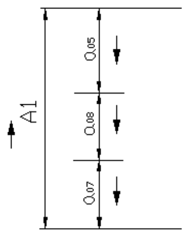


Figure .13 Roller sleeve assembly dimension chain   Fig.14 on the frame assembly tolerances

Upper frame assembly tolerance analysis. The frame assembly tolerance A1 main factors are B1 namely a_{05}, B_2 namely a_{08} (intermediate plate tolerance of ±0.05), B_3 namely a_{07} (bearing surface to the frame plane tolerance of ±0.05mm).

$$A_1=a_{05}+a_{08}+a_{07},\ A_{1max}=0.142+0.05+0.05=0.242$$

$$A_{1min}=-0.2505-0.05-0.05=-0.1505,\ A_1=0^{+0.242}_{-0.1505}$$

Thus, the tolerance value is also greater than the upper frame drawings of ±0.15 mm.

Segment assembly quality assurance process measures

In order to ensure the precision of the assembly process will be given to drawing tolerances sharing, mainly to be adjusted for large impact factors. Adjustment principle is: the tolerance for the large coefficient of freedom to be open, simple and easy to deal with the tolerance given to the provisions. From the above tolerance analysis, the main impact factor is the roller assembly B_1 (roller assembly tolerance a_{05}), while the main factors affecting B_1, a_{02}, a_{04}. The following is a list of the tolerances given to the specified parts.

Roller Assembly Control Measures. (1) Roller assembly tolerances (a_{05}) controlled by $a_{05}= 0^{+0.142}_{-0.2505}$ becomes $a_{05}= 0^{+0.072}_{-0.0805}$. Roller sleeve diameter tolerance of $\varphi\pm0.1$ is defined as $\varphi^{+0.06}_{0}$. Bearing center hole to the bottom plane tolerance $L\pm0.1$ is defined as $L^{+0.05}_{+0.02}$. Change dimension chain Figure 15:

①Base into the hole center distance L size chain a_{02}: closed loop $a_{02}=a_5-(a_0+a_{01})$, $a_{max}=0.05-(0.008+0)=0.042$, $a_{min}=0.02-(0.0355+0.0325)=-0.048$, $a_{02}= 0^{+0.042}_{-0.048}$.

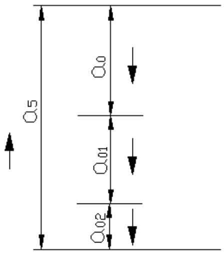


Fig.15 bearing center whole assembly dimension chain

②Spindle center to the outer diameter of the roller sleeve chain a04: closed loop $a_{04}=a_8-a_{03}$, $a_{max}=0.06/2-0 = 0.03$, $a_{min}=0/2-(0.0325)=-0.0325$, $a_{04}=0+0.03-0.0325$.

③Roller assembly tolerance closed loop is: $a_{05}=a_{02}+a_{04}$, $a_{max}=0.042+0.03=0.072$, $a_{min}=-0.048+(-0.0325)=-0.0805$, $a_{05} = 0^{+0.072}_{-0.0805}$.

(2)On the frame tolerance B_3 (a_{07}) controlled $a_{07}{}^{+0.03}_{-0}$; (3) intermediate plate tolerance B_2 (a_{08}) controlled $a_{08}{}^{+0.01}_{-0.01}$; (4) tolerance value adjusted A_1.

$$A_1=a_{05}+a_{08}+a_{07}$$

$$A_{1max}=0.072+0.01+0.03=0.112$$

$$A_{1min}=-0.0805-0.01-0= -0.0905$$

$A_1= 0^{+0.112}_{-0.0905}$ meet the requirements of the drawings±0.15mm

Process Control Points. (1) Bearing the center hole to the bottom plane tolerance $L\pm0.1$ is defined $L^{+0.05}_{+0.02}$. (2) Roller sleeve diameter tolerance $\Phi\pm0.1$ is defined as $\Phi^{+0.06}_{0}$. (3) On the frame tolerance $Y\pm0.05$ That B_3(a_{07}) controlled $a_{07}{}^{+0.03}_{-0}$. (4) An intermediate plate Tolerance $T\pm0.05$ is B_2 (a08) controlled $a_{08}\pm0.01$.

Conclusion

After the above process analysis and calculations, assembly process billets key segments of the size of the opening height the guarantee, at the same time by calculating that each roller assembly quality has been effectively guaranteed, process control measures are in line with the quality requirements for the sector Section of the correct assembly laid a foundation.

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