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FOREIGN TECHNOLOGY DIVISION

IMPROVEMENT OF THE TECHNOLOGICAL PROCESS
OF FORGING OF TURBINE DISKS

By

V. N. Tokarev

79

EDITED TRANSLATION

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IMPROVEMENT OF THE TECHNOLOGICAL PROCESS OF FORGING OF TURBINE DISKS

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	sinh^{-1}
cos	cos	ch	cosh	arc ch	cosh^{-1}
tg	tan	th	tanh	arc th	tanh^{-1}
ctg	cot	cth	coth	arc cth	coth^{-1}
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

0028

IMPROVEMENT OF THE TECHNOLOGICAL PROCESS OF FORGING OF TURBINE DISKS

V. N. Tokarev.

The search for new technological reserves of raising the quality of forgings of turbine disks is an important problem in the matter of raising the reliability and durability of power machines.

To a considerable degree the quality of large forgings is connected with the quality of the central zone of the initial ingot. The increased gas saturation of this zone, the greatest concentration of defects of shrinkage and liquation character in it, and also nonmetallic inclusions are the main causes of rejects.

The main operation of the shaping of disk forgings is the operation of upsetting. Due to the nonuniformity of distribution of deformations in the blank being upset the defects of the central zone of the ingot are most often arranged in the middle along the height of the part of the disk.

One of the directions of the improvement of technological processes of forging of large turbine disks for the purpose of raising their quality is the search for methods of maximum removal of the central zone of the initial ingot, most saturated by metallurgical defects, and also development of methods of forging, providing decrease of the spread of this zone in the forging.

In this respect the method of manufacture of turbine disks from a hollow blank with convex internal surface, applied at Uralmashzavod (Ural Heavy Machinery Plant), is effective.

For further improvement of the quality of forgings at the Neva Machine-building Plant im. V. I. Lenin there is developed and introduced into production the method of manufacture of turbine disks with two broaches of the intermediate blank before its drawing on a mandrel, providing even greater removal of the central zone of the initial ingot (Fig. 1).

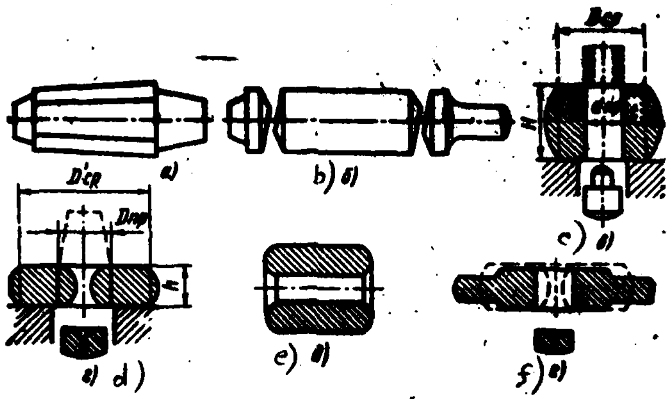

Fig. 1. Diagram of new technological process of forging of turbine disks: a - ingot; b - blank; c - first upset and first broaching; d - second upset and second broaching; e - drawing on mandrel; f - upsetting, dispersal of blade and broaching of finished forging.

The nonuniformity of distribution of deformations in connnection with the presence of contact friction determines the expediency of broaching of the intermediate blank with its greatest possible height by a broach of the greatest possible diameter.

An important condition, determining the selection of the height of the upset blank, is the provision of such a relationship of its dimensions after broaching, at which the next upsetting would be accompanied by decrease of the diameter of the opening. There are taken the following relationships of dimensions of the intermediate blank and broach with the first broaching (see Fig. 1, c):

$$H = 2{,}5\,t;\ d_{\text{пр}} = (0{,}3 \div 0{,}4)\,D_{\text{ср}}.$$

The height of the intermediate blank, determined by the given relationships, is responsible for the relatively low degree of upsetting.

With a small degree of initial upsetting the distribution of the central zone of the initial ingot in radial direction is small, which contributes to a rather high degree of its removal with subsequent broaching.

For increase of the volume of metal scrap in the process of the first broaching it is more preferable to apply a hollow broach and perform broaching by the diagram shown in Fig. 1 c. With such a method (without preliminary pressing of the broach into the blank, lying on a flat plate) the volume of metal scrap will be maximum.

However, for decrease of the mass of blank in several cases (with the use of relatively small ingots) there is not excluded the application of a solid broach and the execution of broaching with preliminary pressing of the broach into the blank.

In the process of the next upsetting of the broached blank the direction of flow of layers of metal adjacent to the hole is changed to the opposite, which significantly reduces the distribution of the central zone of the ingot in radial direction in comparison with its distribution in an upset solid blank.

Final upsetting of the blank is accomplished up to a height of 0.25 D'_{cp} (see Fig. 1 d).

By the relationship of the heights of preliminarily and finally upset blank (H:h>2) there is provided a sufficient degree of deformation, at which the diameter of the hole is noticeably decreased.

The broached blank should be upset by a wide flat face with large coggings, since in this case the filling up of the opening occurs the most intensively.

The diameter of the second broach is determined by the relationship, similar to that taken during the first broaching

$$D_{np} = (0{,}35 \div 0{,}4)\,D'_{cp}.$$

The construction of the broach, applied during the second broaching, is not significant in connection with the relatively small height of the blank and the presence of the hole in it.

In the process of the seconi broaching a significant volume of metal is additionally removed. In this case due to the nonuniformity of deformation, caused by the presence of contact friction, into the scrap metal falls the most defective zone of the initial ingot, adjacent to the internal surface of the blank at the middle of its height.

By the relationship of dimensions of the finally broached blank there is provided the possibility of execution of the subsequent operation of drawing on a mandrel

$$\left(\frac{D'_{cp}-D_{np}}{2h}=1{,}25\right).$$

In the process of drawing on a mandrel (see Fig. 1 e) the diameter of the hole in the blank can be reduced (forged) to the necessary dimension.

Then the blank (see Fig. 1 f) is upset to the height, equal to the height of the boss (taking into account shear drag) and fullered down by blade extensible faces, which also decreases the spread of the central zone of the initial ingot in the forging in comparison with its spread during upsetting of hollow blank in two rings.

The final broaching of the forging is performed by the broach, providing normal allowance for machining of the hole.

For simplification of the calculation of the technological process it is possible to use the graph (Fig. 2), developed taking the accepted relationships into account.

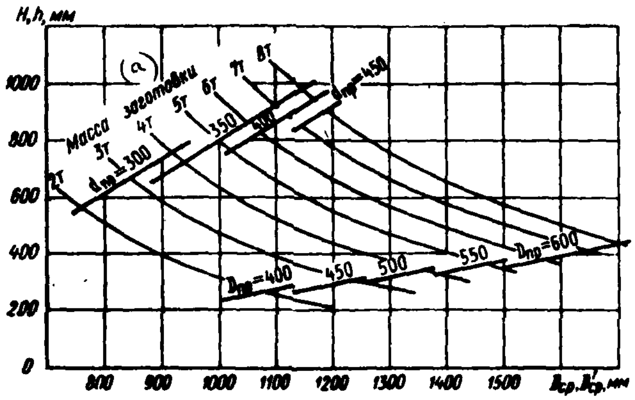

Fig. 2. Graph for determining the heights of upset blanks and the diameters of broaches.

Key: (a) Mass of blank.

The needed dimensions of the heights of the upset blanks (H, h) and the diameters of the broached holes ($d_{пр}$; $D_{пр}$) are found by the graph depending on the mass of the blank.

For ingots of comparatively low weight the second broaching cannot be done or the hole cannot be broached with a diameter smaller than that stipulated by the graph. The height of the blank after the second upsetting should be somewhat reduced for preservation of the relationship of the thickness of the wall of the blank and its height, normal for drawing on a mandrel.

For separate cases of the manufacture of disks with relatively small height of boss and with large hole in the forging, at which the volume of metal scrap with the first broaching and the overall forging reduction factor are rather great, there can not be performed upsetting of the blank after the first broaching, the second broaching and drawing on a mandrel. The blanks in this case can be subjected to intermediate annealing immediately after the first broaching.

The given versions of the technological processes can be recommended not only for forgings of disks, requiring intermediate annealing of the hollow blank in the process of manufacture, but also for steel blanks with relatively low susception to flocculation, and also for large forgings of vacuum steel, when intermediate annealing is not mandatory for provision of the necessary quality of metal.

As a result of the introduction of the new method of forging of turbine disks into production the reject of blanks for metallurgical defects was sharply reduced and the quality of parts was improved.

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