

The invention relates to a process and a device as described in the preamble of Claim 7 for the production of continuous casting moulds for continuous casting machines, wherein firstly an abutment for a mandrel, which possesses the final internal dimensions and/or shape of the mould which is to be produced, is formed onto one end of a pipe section made of copper or a copper alloy, the mandrel is introduced into the pipe section for the calibration of the pipe section, the pipe section is then smoothed onto the mandrel by means of a die, and following the completion of the forming process the mandrel is removed again from the calibrated pipe section.

Such a process has already been fundamentally disclosed in the production of curved continuous casting moulds for arcuate continuous casting machines (DE-PS 18 09 633). Here a mandrel, which possesses the final internal dimensions and shape of the mould which is to be produced, is impressed into a straight pipe section, the outer dimensions of said mandrel being only slightly smaller than the internal dimensions of the pipe section. The pipe section is preformed in accordance with the dimensions of the mandrel, whereupon mandrel and pipe section are jointly urged through a die in order that the inner surfaces of the pipe section be pressed tightly onto the mandrel. This process has given satisfactory results until the present day, facilitating the production of tubular moulds of high dimensional accuracy and surface quality and also of adequate hardness for use in the continuous casting of steel. Although the quality of the tubular moulds produced in accordance with the known process still complies with the current standard, the process itself requires a high outlay in terms of machinery and personnel, and an efficient production technology is not available.

To this must be added the fact that, in order to improve the efficiency of existing casting apparatus, larger moulds are being used to an increasing extent. To avoid periods of disuse resulting from the necessary replacement of the moulds, the service life of the moulds must be extended. For this purpose it is necessary to increase the hardness of the materials which are used for the mould and to improve the shape accuracy of the moulds which are used. The necessity to process materials, in particular copper materials, of increased hardness together with improved shape accuracy of the moulds obliges the mould manufacturer to employ more powerful forming and re-forming forces than were previously necessary in the case of the process described in the introduction.

In another known process (GB-A-21 51 162), for the production of curved continuous casting moulds, a straight pipe section flanged at one end is introduced, in a separate operating step, into a curved die, radial forces being applied to the outer surface of the pipe section. A mandrel possessing the final internal dimensions and shape of the mould which is to be produced is then introduced into the preformed pipe section, whereupon the pipe section is formed onto the mandrel.

Commencing from this prior art, the aim of the present invention is to render the production of continuous casting moulds of arbitrary dimensions and cross-sectional shapes substantially more efficient and thus more cost-favourable and at the same time to improve the quality of the end product, independently of the pipe cross-section, the wall thickness, and the degrees of hardness of the mould materials which are used.

This aim is fulfilled, in accordance with the invention, in that, as described in Claims 1 and 7, during the forming process the die is continuously adjusted into the respective operating position relative to the surface of the mandrel or tool in dependence upon the radius of curvature of the mandrel or the tool surfaces during the relative movement between the pipe section and the die.

The process steps in accordance with the invention permit a more efficient production with improved quality of the end product. This also applies, in particular, to the production of tubular moulds with larger geometric dimensions adapted to requirements and made of harder mould materials. The production procedure can take place in semi- and fully automatically controlled fashion in accordance with the job requirements, whereby the process becomes independent of manual handling errors.

The process permits selective job processing within a predetermined production programme, with the avoidance of noticeable interruptions due to refitting. The orderly execution of the production programme requires a starting material store containing the number of pipe preforms, optionally of different dimensions, required for processing. These preforms can consist of straight or also already pre-curved pipe sections cut to the required length. The starting material from which the pipe sections are cut to length advantageously consists of drawn pipe lengths, although rolled or cast pipe lengths can also be used as basic materials for the pipe sections to be processed in accordance with the invention.

For the production of continuous casting moulds for continuous casting machines, expediently firstly an abutment for the mandrel which is to be introduced is arranged at one end of a pipe section. Such an abutment can consist of a mandrel which is passed through the end of the pipe section, or one end of the pipe section can also be formed into a point in an appropriate fashion to prevent the mandrel from being pushed or drawn through the pipe section when it is introduced therein. However, in accordance with the efficient production in accordance with the invention, it has proved particularly advantageous to cup one end of the pipe section for this purpose. Here "cupping" is to be understood as the inward flanging of the edges of the end of the pipe section.

An essential feature of the invention consists in that the forming of the pipe section into a tubular mould, and in particular the cold forming, in order to obtain the required mould qualities, such as dimensional accuracy, surface quality of the inner surfaces which form the mould cavity, hardness of the pipe walls, is achieved by means of a mandrel which possesses the final internal dimensions

of the tubular mould. Generally the mandrel will be impressed into the pipe section, and this is the case even when, for example, curved tubular moulds are to be produced and straight pipe sections, into which a curved mandrel is to be introduced, are taken from the starting material store. Without departing from the principle of the invention, the introduction of the calibrating mandrel into the pipe section which is to be formed naturally can also be carried out in such manner that the mandrel is introduced into the pipe section - curved or straight - with play and the mechanical contacting does not take place until during the forming process.

For the acquisition of the desired mould qualities, an essential feature of the invention consists of a die, by which the pipe section, which has been expanded by means of the mandrel (mandrel-pipe section combination), is smoothed onto the mandrel, i.e. is mechanically formed onto the mandrel so as to make intimate contact on all sides. For this purpose the expanded pipe section can be pushed or drawn through the die, but in a further development of the invention the die can also be moved over the stationary, expanded pipe section for the purpose of forming the pipe. The intimate pressing of the inner surfaces of the pipe section onto the mandrel permits the production of straight or curved, conical or partially conical tubular moulds characterised by particularly good dimensional accuracy, high surface quality and hardness adequate for use in the continuous casting of steel, the process in accordance with the invention ensuring uniform mould qualities by means of a cost-favourable mode of operation.

If, as also provided in a further development of the invention, during the forming process the die is continuously adjusted into the respective operating position relative to the surface of the mandrel or tool in dependence upon the radius of curvature of the mandrel or the tool surfaces during the relative movement between the pipe section and the die, then in spite of more powerful forming forces, e.g. in the case of the forming of an expanded pipe section onto the calibrating mandrel, this measure leads to a uniform removal of material in the execution of the process and thus to a uniform wall thickness which is free of internal, mechanical tensions. These characteristics, which can be achieved by means of the invention, result in a substantial increase in service life. This applies in particular when, in accordance with the execution of the invention, the die is continuously adjusted into the respective position normal to the surface of the mandrel or tool in dependence upon the radius of curvature of the mandrel or the tool surfaces during the relative movement between the pipe section and the die.

Furthermore, by virtue of the continuous adjustment of the die into the respective operating position, the invention facilitates a deliberate adjustment of the die during the forming process, e.g. in order to adjust the wall thickness of pipe sections which do not have equal walls and which are supplied to the forming device as starting material. Arbitrary angular adjustments, for example with

respect to the mandrel central axis, can be attained. These facilities are not provided by known devices (DE-PS 21 54 226) and processes (EP-PS 0 060 820). Thus the automatic advance of the die in the direction of the curved mandrel can lead to non-uniform removal of material and unequal walls of the tubular mould. The drawing of the pipe section over an externally applied, curved tool surface also does not achieve the desired effect, and in particular it is not possible to achieve the required dimensional accuracies of the inner surfaces of the tubular mould in this way.

A particularly advantageous embodiment of the invention is obtained if, as already indicated, a curved mandrel possessing the final internal dimensions and/or shape of the tubular mould which is to be produced is introduced into the pipe section and the expanded pipe section is formed onto the mandrel by a pivotably mounted die. By virtue of the fact that, at each moment of the relative movement between the expanded pipe section and the die, the latter extends perpendicularly to the radius of curvature of the mandrel, a uniform shaping of the pipe walls is ensured. This is because the forming process by the "smoothing" of the pipe section onto the mandrel is continuously actively influenced.

The relative movement between the pipe section, in particular the expanded pipe section, and the die is fundamental to the forming process according to the invention. Therefore it is basically immaterial as regards the forming process as to whether the pipe section is pushed or drawn through the die. If, in order to improve the dimensional accuracy of the shaping interior, a mandrel possessing the final internal dimensions and/or shape of the mould is arranged in the pipe section, it can often be expedient to guide the die over the expanded pipe section in the axial direction of the mandrel.

However, the invention results in yet a further advantage. The, for example, drawn pipes which are used as starting material and are then cut to pipe sections of the required length, generally possess a specific tolerance in respect of eccentricity of wall thickness. By means of the adjustment of the die, to be achieved in accordance with the invention, during the calibration of the tubular mould it is possible to eliminate these irregularities originating from the so-called pipe preform.

The die itself is guided, for example, in a so-called die holder. Therefore, in accordance with the execution of the invention, the continuous adjustment into the position normal to the mandrel surface is achieved by applying force to the die holder, which is rotatably or pivotably mounted and which maintains the die in a stable position relative to the die holder. Advantageously, in particular because of the powerful forming forces, the die holder will be adjusted hydraulically into the respective operating position, for example into the position normal to the radius of curvature of the mandrel or the tool surfaces.

In addition to a high quality expectation, the efficiency of the forming process also represents an essential feature of the invention. For this reason, in a further development of the principle of the invention, it is provided that the adjusting movement of the die into the respective operating position relative to the surface of the mandrel or the tool surfaces takes place via a freely programmable control arrangement. Depending upon the pipe dimensions, wall thicknesses, material characteristics, radii of curvature and the like, i.e. job-dependent parameters, the adjustment into the operating position in dependence upon the respective radius of curvature takes place automatically in accordance with a predetermined programme.

Another advantageous possibility of implementing the invention consists in that the adjusting movement of the die into the perpendicular position or into any other operating position forming arbitrary adjustment angles between the die and the mandrel surface or tool surfaces, is carried out by automatic adjustment in dependence upon a force measurement between the die holder and the machine frame.

Following the forming, which preferably consists of cold forming and expediently provides forming degrees of between 15 and 25% relative to the starting cross-section of the pipe section, when pipe sections already adapted to the final dimensions and/or shape are used as starting material, the calibrating mandrel is pushed or drawn out of the now formed, tubular mould. Optionally the tubular mould (calibrated pipe section) is cut to the final dimensions and the, for example, cupped pipe end is also removed. The tubular mould produced in this manner can either then, following quality checking, be packaged and prepared for dispatch, or prior to the quality control can also be series-produced by mechanical processing, i.e. for example, the end sides of the tubular mould can be additionally mechanically processed and retaining grooves can be milled into the pipe walls from the exterior.

The process in accordance with the invention can be applied to arbitrary mould cross-sectional shapes, subject to a mandrel shape corresponding to the desired cross-sectional formation of the mould. Thus circular, rectangular, square or polygonal cross-sectional shapes can be obtained, as well as T-, double-T-, U- or L-shaped cross-sectional profiles.

In accordance with the execution of the invention, the mandrel required for the forming in accordance with the desired cross-sectional shape can also be conically shaped, either singly or multiply, in order to achieve the optionally required conicity of the mould cavity. The mandrel can also be curved to enable tubular moulds produced in accordance with the invention also to be used in the case of arcuate continuous casting machines.

The different profiling of the mould cavity can lead to undercuts in the shaping of the calibrating mandrel. In such cases, in order to prevent from the start problems connected with the pushing or drawing of the mandrel out of the tubular mould, it has

proved expedient to doubly or multiply divide the mandrel. The division of the mandrel can extend in the longitudinal and/or transverse direction relative to the axial direction of the mould.

The invention will be explained in detail making reference to the exemplary embodiments illustrated in Figures 1 to 6. Here Figures 1 and 2 illustrate the process flow according to the invention, whilst Figures 3 to 6 illustrate the concrete example of the adjustment of the die into the operating position.

For the production of curved tubular moulds in accordance with the invention, from a store SR of pipe sections cut to the required length, and possibly of different dimensions and/or cross-sectional shapes, the pipe section 1 suitable for a predetermined type of mould is selected and conveyed to the station I for cupping. This "cupping", i.e. flanging of the pipe end 2, expediently is carried out, following the fixing of the supplied pipe section 1 in a suitable pressing device, by compressing one end of the pipe. The cupped pipe section 1 is conveyed to the station II by means of a suitable transport device, whilst at the same time the calibrating mandrel 3, specified in dependence upon the job requirements, is removed from the mandrel store SD and likewise conveyed to the station II in which it is impressed for example into the still straight pipe section 1 in a kind of lathe. The expanded pipe section 1 thus already automatically assumes the approximate shape of the mandrel.

Another possibility consists in that the already curved pipe section 4 is removed from the store SR, is cupped in the station I and the curved mandrel 3 is then inserted in the station II, i.e. depending upon the conformity in terms of shape and dimensions, the mandrel is slid or pushed into the pipe section.

Independently of the association between the pipe section and the mandrel, i.e. straight-curved or curved-curved, the decisive forming process is carried out in the station III. Here the pipe section 1 is smoothed onto the mandrel 3 with the assistance of the die 5. In the illustrated embodiment, for this purpose the expanded pipe section (1/3) is urged through the die in the direction of the arrow, the inner surface 6 of the pipe section 1 being pressed tightly onto the mandrel surface. In this forming of the pipe walls, an increase in the hardness of the pipe material is obtained simultaneously with the copying of the shape and surface of the mandrel.

For the further processing of the now formed tubular mould 1', i.e. optional serial production and quality checking, the mandrel 3 is removed from the tubular mould 1' in the station IV. This is carried out, for example as illustrated in the Figure, by means of a stripper 7 which serves as abutment for the tubular mould 1' when the mandrel 3 is pushed out of the tubular mould 1' in the direction of the arrow.

Following the mechanical separation of the mandrel 3 and the tubular mould 1', as indicated in station V, the mandrel 3 is conveyed to the station II and on completion of a production lot is

returned to the mandrel store SD. The transport belt 8 is used for this purpose. If, in further production lots, straight tubular moulds or tubular moulds with double-T-profiles are provided, the mandrel 9 or the mandrel design 10 will be re-used accordingly. The cupped end 2 of the calibrated pipe section 1 - now the tubular mould 1' - is now removed and, if no further processing of the ends or cutting to the required final dimensions is necessary, the pipe is conveyed to the checking station P. The tubular mould 1' can then be packed and prepared for dispatch.

Figure 2 illustrates the operating system according to the invention in a type of block circuit diagram. In accordance with the specified job, - e.g. production lot: tubular mould, format X-Y: square, material: CuCrZr, partially conical, controlled, - a suitable pipe section is removed from the store SR and conveyed to the station I for cupping. In the meantime the mandrel required for the production lot defined in accordance with the prescribed job is fed from the mandrel store SD to the station II and is introduced into the cupped pipe section supplied from station I. The pipe-mandrel combination now passes to station III in which the pipe section is pressed tightly onto the mandrel surface and finally passes to station IV for the re-separation of the mandrel and the now calibrated pipe section (tubular mould).

From here the calibrated pipe section is conveyed to the checking station P, optionally following final processing, cutting to final dimensions etc., and the mandrel passes firstly to the control station ST which, in accordance with the size of the production lot (number of items of the same mould type) either causes the mandrel to re-enter the station II or, in the event that the type of mould to be produced is subsequently to be changed, causes the mandrel to return to the store SD.

Figures 3 to 6 illustrate details of the forming process on an enlarged scale compared to Figures 1 and 2. The starting material used for forming a pipe section into a tubular mould consists of the bright-drawn, straight copper pipe 11 which is produced by drawing, for example, from an extruded circular pipe and which possesses a Brinell hardness of, for example HB 55-75. This pipe is cut to the desired mould length taking into account a machining allowance. Then, as can be seen from Figure 3, the, for example, hard-chrome-plated mandrel 12, which is manufactured in accordance with the internal dimensions of the mould which is to be produced and which is shaped in accordance with the curvature of the arcuate continuous casting machine, is impressed into the pipe 11 (the pipe is expanded by the mandrel), as illustrated in Figure 4.

As a deviation from the foregoing, the copper pipe 11 can naturally also already be pre-curved in accordance with the shape of the mandrel in order to simplify the insertion of the mandrel, and adequate play between the mandrel surface and the pipe inner surface can also be selected for the same purpose. The copper pipe 11 will be expediently cupped at the end 13, i.e. the pipe end will be inwardly flanged in order to provide an abutment for the inserted

mandrel for the subsequent forming. However, the abutment can also be provided by means of a pin extending transversely through the end of the copper pipe or simply by forming the pipe end 13 into a point.

The expanded copper pipe 11 is then, as can be seen from Figure 5, conveyed to the forming device 14 which substantially consists of the machine frame 15 and the die holder 17 which is mounted on the machine frame 15 by means of the schematically indicated rotating or pivoting device 16 and which contains the die 18. 19 designates hydraulic cylinders which abut against the material frame 15 and which, on the actuation of an appropriate control arrangement, pivot the die holder 17, as indicated by arrows, with respect to the machine frame 15.

In this way, as illustrated in Figure 6, it is possible at any point in time of the passage (drawing or pushing) of the expanded copper pipe 11 through the die 18, to adjust, for example, the ideal position of the die, i.e. the position of the die normal to the mandrel surface. The continuous forming process consisting of the tight pressing or smoothing of the copper pipe 11 onto the mandrel 12 can thus be actively influenced in terms of a uniform wall thickness and in terms of a uniform distribution of tension and an improvement in the mould service life. This possibility is of particular significance when larger dimensions and harder mould materials are adopted.

The common pushing of copper pipe 11 and mandrel 12 through the die 18, which has been adjusted in accordance with the curvature of the mandrel, in the exemplary embodiment into the position normal i.e. at right angles, to the mandrel surface, leads, as a result of the cold forming which takes place here, to absolute dimensional accuracy of the mould 11' produced in this way, and the Brinell hardness is simultaneously increased from the original value to HB 80 - 110.

As also indicated in Figures 5 and 6, the adjustment of the respective position of the die 18 relative to the mandrel surface can be carried out with the assistance of force measuring devices 20 which are arranged at different locations of the die holder 17 between the die holder 17 and the machine frame 15. The differences in the occurring, measured forces are analysed in the data processing unit 21, for example via microprocessors known per se, and converted into control commands for adjusting the die into the perpendicular position. In this way the forming process can be automatically optimised on the basis of the job data, i.e. for highly differing dimensions, cross-sections, wall thicknesses etc., and for highly differing shapes and material qualities.



CLAIMS

1. A process for the production of continuous casting moulds for continuous casting machines, wherein firstly an abutment for a mandrel, which possesses the final internal dimensions and/or shape of the mould which is to be produced, is formed onto one end of a pipe section made of copper or a copper alloy, the mandrel is introduced into the pipe section for the calibration of the pipe section, the pipe section is then smoothed onto the mandrel by means of a die, and following the forming process the mandrel is removed again from the calibrated pipe section, characterised in that during the forming process the die (5;18) is continuously adjusted into the respective operating position relative to the surface of the mandrel or tool in dependence upon the radius of curvature of the mandrel (3;12) or the tool surfaces during the relative movement between the pipe section (1;4;11) and the die (5;18).
2. A process as claimed in Claim 1, characterised in that during the forming process the die (5;18) is continuously adjusted into the respective position normal to the surface of the mandrel or tool in dependence upon the radius of curvature of the mandrel (3;12) or the tool surfaces during the relative movement between the pipe section (1;4;11) and the die (5;18).
3. A process as claimed in Claim 1 or 2, characterised in that the continuous adjustment of the die (5;18) into the respective operating position is carried out by applying force to the die holder (17) which is rotatably or pivotably mounted and maintains the die (5;18) in a stable position relative to the die holder (17).
4. A process as claimed in one of Claims 1 to 3, characterised in that the die holder (17) is adjusted hydraulically or mechanically into the respective operating position.
5. A process as claimed in one of Claims 1 to 4, characterised in that the adjusting movement of the die (5; 18) into the respective operating position is carried out via a freely programmable control arrangement.
6. A process as claimed in one of Claims 1 to 5, characterised in that the adjusting movement of the die (5; 18) into the respective operating position is carried out by automatic regulation in dependence upon a force measurement between the die holder (17) and the machine frame (15).
7. A device for the production of continuous casting moulds for continuous casting machines, comprising a mandrel, which can be introduced into a pipe section and which possesses the final internal dimensions and/or shape, and a die by which the pipe section passing through it is formed onto the mandrel, characterised by a rotatably



or pivotably mounted die (5;18) with an adjustment facility hydraulically actuated in dependence upon control signals.

8. A device as claimed in Claim 7, characterised in that the mandrel (3;9;10;12) possesses a shape which is conical or partially conical in the longitudinal direction.

9. A device as claimed in Claim 7 or 8, characterised in that the mandrel (3;9;10;12) is doubly or multiply divided.

10. A device as claimed in Claim 9, characterised in that the division of the mandrel (3;9;10;12) extends longitudinally and/or transversely relative to the axial direction.