Improve Productivity for Warm Ring Rolling Process of Bearing Race

1. Preface

Machine component manufacturers across the globe have long faced the challenge of improving productivity in order to reduce production costs. To this end, NTN-SNR has been applying a warm ring rolling process to the production of its bearing raceways, eliminating the need for a turning process. In order to further improve the effectiveness of the warm ring rolling process, NTN-SNR has been optimizing a numerical simulation technique that aids in the warm ring rolling process. In this article, we report our efforts toward improving our warm roll-forging technique, taking the outer ring of a double-row angular contact ball bearing as a typical work piece.

2. Structure and features of warm roll-forging system

Fig. 1 schematically illustrates difference between a conventional roll-forging technique and NTN-SNR’s unique warm roll-forging technique.

In the conventional roll-forging technique, the rotating roll-forming tool is forced to the bore surface of the work piece blank to form the blank into its intended cross-sectional shape and enlarge the blank to its target diameter while reducing the blank wall thickness.

NTN-SNR’s warm roll-forging system is very unique in that a work piece blank is placed in two outer circumferential profile regulating dies, whereupon the spirally-moving roll-forming tool is forced against the bore surface of the blank to form the blank into its intended cross-sectional shape and enlarge the blank to its target diameter.

As schematically illustrated in Fig. 2, the outer circumferential profile of a work piece blank is regulated with the outer dies (1) and (2), ensuring that the profile of the roll-forming tool is accurately transferred to the work piece blank. In summary, NTN-SNR’s unique roll-forging technique produces high-precision ring-shaped bearing components through a rolling process that forms the bore and outer circumferential surfaces without the need for any turning operation.

Fig. 3 offers a diagram showing the spiral trajectory of the roll-forming tool that is a unique feature of the NTN-SNR process. By this spiral motion, a work piece blank is formed to its intended shape and dimensions, simultaneously reducing its wall thickness and enlarging its diameter.

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3. Feature of the NTN-SNR warm-rolling machine, and NTN-SNR’s commitments to improvement in productivity

A view of NTN-SNR’s unique warm-rolling machine is shown in Fig. 4. This machine operates as described below:
1) The roll-forming tool drive causes the roll-forming tool to turn.
2) The roll-forming tool spiral motion drive, rack mechanism actuator, and roll-forming tool push-in drive are linked with each other through gearing to cause the roll-forming tool to follow a spiral trajectory.
3) As indicated in Fig. 2, the outer die (1) is stationary, while the outer die (2) is movable. By operation of the outer die (2), a work piece blank is loaded into the space between the outer rollers and the roll-forming tool; once the work piece has been formed it is removed from the warm-rolling system, again by the movable outer die (2).

The main frame of the machine supports the roll-forming tool. Its inclined angle allows the formed products to be automatically delivered by gravity. In other words, its simple construction removes the need for a product delivery mechanism. Instead of the previous hydraulic drive, the new model of the machine is actuated by an NC system. Consequently, operation of all the mechanisms within the machine is now centrally controlled to inhibit variation in motion that can occur from variations in mechanical components. Furthermore, by fully utilizing position information from the NC controller, simulation accuracy has been improved, resulting in the reduction of rolling cycle time.

3.1 Numerical simulation
To reduce machining cycle time, extend tool life, and decrease setup time for its warm-rolling machine, NTN-SNR has been developing a numerical simulation tool that helps optimize operation of its warm roll-forging process and roll-forming tool.

3.1.1 Temperature analysis
An example of the results of temperature analysis on various areas of the warm-rolling machine during the warm roll-forging process is given below. Fig. 5 illustrates the temperature distribution on a work piece blank during warm roll-forging; Fig. 6 shows the temperature distribution on the outer dies; and Fig. 7 provides the temperature distribution on the roll-forming tool. Fig. 8 provides a comparison between the values resulting from numerical simulation and empirically measured values by plotting the time elapsed and temperatures occurring
on the roll-forming tool during warm roll-forging operation.

From this diagram, it can be seen that the result of numerical simulation closely matches the measured values for temperatures of the roll-forming tool, both at its outer surface and within the tool (20 mm beneath the surface). In other words, the numerical simulation tool developed by NTN-SNR exhibits a very high degree of accuracy.

3.1.2 Analysis for stress and deformation

Fig. 9 offers an example of the results of analysis on stresses occurring on the roll-forming tool during warm roll-forging, while Fig. 10 illustrates the results of deformation analysis in the same situation.

Fig. 11 illustrates the relation between run time of the above-mentioned machine and load applied to the roll-forming tool in the machine during warm roll-forging. Differences in various data sets between the pre-operation analytical values and the actual values obtained from the machine during operation were fed back to the simulation system. Then, reanalysis was
performed using the newly-fed data: It was found that, in terms of the peak load acting on the roll-forming tool, the analytical values (post-operation) closely match the measured values. This means that our simulation method fairly accurately represents the timing and magnitude of the peak load applied to the roll-forming tool during roll-forming operation.

Fig. 11 Load applied to roll-forming tool during rolling

4. Conclusion

Through improvement of its numerical simulation technique for warm ring rolling process, NTN-SNR has been endeavoring to optimize process conditions, while always remaining careful not to deteriorate the effective life of the roll-forming tool.

By our efforts, we have achieved approximately 20% reduction in cycle time, compared with the previous technique, as shown in Fig. 12.

NTN-SNR will remain committed to developing new technologies targeting improved productivity, reduced scrap production, and simplified processes. Further improvement in its forging technology is to be capable of forming more complicated, medium-sized ring-shaped bearing components. In doing so, NTN-SNR will remain fully conscious of the conservation of the global environment.

Fig. 12 Cycle time

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