Improvement of rolling modes of long length rails on the universal rail and structural steel mill “EVRAZ ZSMK”

A V Golovatenko¹, A A Umansky² and V N Kadykov³

¹ JSC “EVRAZ Consolidated West Siberian Metallurgical Plant”, Novokuznetsk, 654000, Russia
² Department of Metallurgy of Ferrous Metals, Siberian State Industrial University, 42 Kirova Street, Novokuznetsk, 654007, Russia
³ Department of Metal Forming and Material Science. “EVRAZ ZSMK”, Siberian State Industrial University, 42 Kirova Street, Novokuznetsk, 654007, Russia

E-mail: umanskii@bk.ru

Abstract. Using the results of theoretical and experimental research a new rolling mode of long-length rails on the universal rail-and-structural steel mill JSC “EVRAZ Consolidated West Siberian Metallurgical Plant” (“EVRAZ ZSMK”) was developed with a reduced number of passes in the breakdown stands. Experimental and industrial testing and implementation of the new rolling mode showed a high technical and economic efficiency of its use – reduction in the specific energy consumption was registered, as well as decrease in rejection of rails due to their surface defects, consumption of mill rolls and increase in mill productivity. The cost-effectiveness after implementation was more than 98 million RUB per year.

1. Introduction

The improvement of rolling modes, including grooving of rolls, is the most important reserve for the energy efficiency increase in the rolling production and quality improvement of the finished sections [1]. To the maximum extent this statement is valid with respect to the shaped sections of a complex shape, including rail sections [2-9].

In 2013 “EVRAZ ZSMK” was the first in Russia to put into operation an universal rail-and-structural steel mill. Its main product is differentially hardened long-length rails (up to 100 m long) [10]. In accordance with the contract grooving of the equipment supplier (company “SMS Meer” Germany) the rolling scheme includes the following steps (Figure 1). Deformation in the first breakdown stand BD1 is done in 7 passes, of which the first 6 passes are carried out in the box groove, and the last one – in the groove “recumbent trapeze”.
Figure 1. The contract rolls grooving for rolling rails R65 on the on universal rail-and-structural steel mill “EVRAZ ZSMK”.

Rolling in the second breakdown stand BD2 was performed in 5 passes: the first pass – in the trapezoidal groove without cutting from the side of the future rail base; the second and third passes – in the first closed rail groove of “beam-type”; the fourth pass – in the second closed rail groove of “beam-type”; the fifth pass – in the open symmetrical rail groove. After rolling in the breakdown stands the rolled piece is forwarded for the further deformation into a continuous group of stands, which is carried out in three passes: the first pass – continuous rolling in the first universal stand (UR) and subsidiary stand (ER), the rolls of the second universal stand (UF) are driven apart; the second pass – in the first universal stand (UR) after its reversing with the driven apart rolls of the subsidiary stand (ER); the third pass – continuous rolling in all three stands of the groups (UR, ER, UF).

The start-up and initial period of operation of the universal rail-and-structural steel mill revealed the significant deficiencies in the contract grooving of company “SMS Meer” and the significant reserves for improving the rolling mode.

In the usage of the contractual grooving the bending the front end of the feed took place during rolling in the second rail groove (the second and third passes in stand BD2) and in the symmetrical rail groove (the fifth pass in the stand BD2), which led to the need for rolling with “starting” of the stock in the indicated passes. As a result of this mode the formation of “rolling skin” on the rails surface occurred.

The mechanism of this defect consists in the rolling of the existing mechanical damages of the stock surface during rolling [11]. Further, rolling with “priming” resulted in the decrease of rolls durability due to the increased mill rolls production and the increase in the rolling time in the breakdown stand BD2. Thus, in practice, it was shown that the use of the contract mode of rails rolling was low-tech, and led to a significant deterioration of the technical and economic operational performance of the rail-and-structural steel mill and the decline in the quality of finished products.

2. Results and discussion

In order to eliminate these disadvantages of the contract mode of rails rolling on the universal rail-and-structural steel mill “EVRAZ ZSMK” a new intensified rolling mode was developed with a reduced number of passes in the second breakdown stand BD2 (Figure 2).
Using the new rolling mode the deformation in the stand BD1, as well as using the contract scheme, is carried out in 7 passes. However, the rolling in the box grooves is performed only in the first 5 passes, in the sixth pass the deformation is achieved in the groove “recumbent trapeze”, and in the seventh pass – in the trapezoidal groove.

Rolling in the stand BD2 is done in 3 passes: the first and second passes are carried out in the “oblique located” rail grooves with slopes of the side walls up to 18% and use of thrust cones with slopes up to 25%, and the last pass – in the open symmetrical rail groove. After BD stands the stock, as in the contract rolling scheme, is forwarded for the further deformation in the stands of continuous group. The rolling scheme in the continuous group of stands remained unchanged.

The possibility for reducing the number of passes was proved by the calculations of the rolling force in BD stands, which were done according to the previously developed calculation methods of the deformation resistance [12]. Based on the obtained data using the new rolling mode the rolling force will not exceed 61% of the permissible values (Figure 3).
To determine the producibility of the new rolling mode the pilot industrial tests of the engines load in the BD stands of the universal rail-and-structural steel mill “EVRAZ ZSMK” were performed. Three rolling modes were used:

1. Contract mode (7 passes in the stand BD1 and 5 passes in the stand BD2) – mode No. 1;
2. Mode with redistribution of breakdowns between the stands (9 passes in the stand BD1 and 3 passes in the stand BD2) – mode No. 2;
3. The developed intensified mode (7 passes in the stand BD1 and 3 passes in the stand BD2) – mode No. 3.

The research was conducted by the oscillograph method measuring parameters of the engine operation of stands drives.

Both stand BD1 and BD2 are equipped with the same type of synchronous engines of type AMZ 0900LT08 LSB, the technical characteristics of which are summarized in Table 1.

| No. | Parameter                              | Value of the parameter |
|-----|----------------------------------------|------------------------|
| 1   | Rotation nominal speed                 | 310 rot./min           |
| 2   | Rotation maximal speed                 | 982 rot./min           |
| 3   | Current nominal speed                  | 744 A                  |
| 4   | Nominal voltage of starter             | 3165 V                 |
| 5   | Nominal power                          | 4000 kW                |
| 6   | The nominal moment at the motor shaft  |                        |
|     | - at the rotation nominal speed        | 123 kN·m               |
|     | - at maximum speed                     | 39 kN·m                |

For these engines, the following restrictions on overloading of the nominal value in the process:

- Not more than 115% of the nominal value during continuous overload;
- Not more than 225% of the nominal value at overload for 30 seconds;
- Not more than 250% of the nominal value at overload for 2 seconds.

The results obtained after oscillograms processing are shown in Table 2.

On the basis of the conducted analysis we can say that in the process of use of all three rolling schemes the modes of engines operation of stands BD1 and BD2 are within the permissible.

To compare the efficiency of different rolling schemes the specific energy consumption per tonne of the rolled stock is identified. The results are provided in Table 3 and Figure 4.

Table 1. Specifications of engines in the stands BD1 and BD2.

| Stand | Pass No. | Mode No.1 | Mode No.2 | Mode No.3 |
|-------|----------|-----------|-----------|-----------|
|       |          | SM, % from nom. | n, rot./min | SM, % from nom. | n, rot./min | SM, % from nom. | n, rot./min |
| BD1   | 1        | 100       | 370       | 135       | 315       | 110       | 210       |
|       | 2        | 82        | 370       | 110       | 368       | 100       | 370       |
|       | 3        | 105       | 475       | 135       | 485       | 110       | 415       |
|       | 4        | 77        | 463       | 95        | 465       | 80        | 476       |
|       | 5        | 35        | 504       | 40        | 485       | 80        | 476       |
|       | 6        | 30        | 463       | 40        | 465       | 55        | 420       |
|       | 7        | 55        | 525       | 70        | 420       | 76        | 580       |
|       | 8        | -         | -         | 55        | 355       | -         | -         |
|       | 9        | -         | -         | 35        | 537       | -         | -         |
Table 3. Specific energy consumption in different rolling schemes in the stands BD1 and BD2.

| Stand | Specific energy consumption for different rolling schemes, kW·h/tonne |
|-------|---------------------------------------------------------------------|
|       | Mode No.1                | Mode No.2                | Mode No.3                |
| BD1   | 4.23                     | 5.63                     | 5.19                     |
| BD2   | 5.43                     | 4.38                     | 3.96                     |
| Total | 9.66                     | 10.01                    | 9.15                     |

Figure 4. Specific energy consumption for different rolling modes of rails R65 in the BD stands.

According to the data rolling mode No.3 is the most energy efficient: in relation to the contractual scheme of rolling (mode No.1) the decrease of the specific electricity consumption 0.51 kW·h/tonne was registered, and in comparison with the rolling scheme No.2 the specific energy consumption is 0.86 kW·h/tonne less.

During the pilot-industrial approbation and implementation of the intensified mode of breakdowns in the BD stands (mode No.3) the decrease of finished rails rejection due to surface defects was recorded, compared with periods when rolling mode No.1 was used (Figure 5).
The conducted evaluation of the impact of change in the rolling mode on rejection due to the defect “rolling skin” showed that application of the intensified rolling mode reduces rejection for this defect by 0.5%. This is due to the fact that when using the new rolling mode the technological possibility appeared to abandon rolling with “starting” of the stock with the absence of risk for bending of the strip after its leaving grooves of BD stands.

Based on the positive results of pilot testing the rolling mode with a reduced number of passes in the BD stands was adopted as a primary mode for the production of long-length rails on rail rolling mill “EVRAZ ZSMK”.

The introduction of this regime in the rolling production allowed, except for the above-mentioned reduction in specific energy consumption and improvement of the rails surface quality, reduction in specific consumption of rolls for stand BD2 to be reduced by 0.51 kg/tonne, as well as reduction in the cycle on rolling stands by 10 seconds (which led to an increase in productivity of the mill up to 146.8 tonnes/h) and the increase in the rolled products volume between repairs from 3.5 to 6.0 thousand tonnes. The cost-effectiveness of implementation was 98.588 million RUB per year.

3. Conclusions
Based on the results of theoretical and experimental studies developed an intensified mode of rolling of long rails in the rail-and-structural steel mill “EVRAZ ZSMK”. Its main distinctive features are: reduction of passes number in the BD stages (by 2 passes) and substitution of the closed grooves of “beam-type” by “oblique located” rail grooves with the slope of the side-walls up to 18%. The pilot testing of the new rolling mode showed the producibility, technical and economic efficiency of its use, which was a prerequisite for its implementation into production. The cost-effectiveness from its implementation is more than 98 million RUB per year.
4. References

[1] Umanskii A A and Mart’yanov Y A 2014 *Metallurgist* **58** (5–6) 516–523
[2] Shilov V A, Shvarts D L and Litvinov R A 2008 *Univ. Proc. Ferrous Metallurgy* **3** 51–54
[3] Shvarts D L 2015 *Steel in Translation* **45** (6) 430–435
[4] Shvarts D L 2015 *Steel in Translation* **45** (5) 526–530
[5] Shilov V A, Shvarts D L and Litvinov R A 2008 *Rolled Metal Production* **1** 29–32
[6] Stalinskii D V and Rudyuk A S 2011 *Steel in Translation* **41** (5) 73–77
[7] Rudyuk A S, Azarkevich A A, Sidorchuk R S, Karmazin A V and Koshulë I M 2014 *Metallurgist* **57** (9) 845–848
[8] Sinel'nikov V A, Filippov G A 2001 *Metallurgist* **45** (9) 403–407
[9] Smirnov V K, Bondin A R and Mikhailenko A M 2002 *Rolled Metal Production* **12** 24–30
[10] Golovatenko A V, Volkov K V, Aleksandrov I V, Kuznetsov E P, Dorofeev V V and Sapelkon O I 2014 *Ferrous Metallurgy* **6** (1374) 32–38
[11] Trotsan A I, Kaverisky V V, Nosochenko A O and Koshulë I M 2012 *Proceedings of PGTU. Series of Tech. Sc.* **25** 106–114
[12] Umansky A A, Golovatenko A V, Kadykov V N and Dumova L V 2015 *Proc. XIX Int. Conf. on Metallurgy: Technologies, Innovations, Quality* (Novokuznetsk: SibSIU) part 2 pp 110–115