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Review paper

THE LATEST IMPROVEMENTS IN I-BEAMS PRODUCTION IN THE WORLD

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ABSTRACT

Some specific aspects in the state of art regarding the improvements related to I-beams and parallel flanged I-beams production are presented in this paper. One practical solution in the variety of the conversions of the classical to the universal rolling stands is described in some more detail, as well as an overview of the latest improvements in I-beams and parallel flanged I-beams production in the world. So-called INP I-beams have tapered flanges v.s. parallel flanges concerned with parallel flanged I-beams, which are very difficult to be produced on classical rolling mills stands, but much easier and better to be produced on so-called universal rolling stands. Since the universal stands are expensive and are very difficult to fix at the existing rolling mills with classical rolling stands, then a conversion of classical to the universal rolling mills stands is the cheapest satisfactory solution. In a short overview are as well presented state of art technological improvements in parallel flanged I-beams production.

Keywords: rolling of I-beams; parallel flanged I-beams production, conversion of a classical rolling stand; universal rolling stand

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1. INTRODUCTION

I-beams production started about 3 centuries ago and will last forever. Rolling of I-beams can be performed at the classical rolling mills, but nowadays for the parallel flanged I-beams is necessary to have the universal rolling stands, or to make a conversion of the classical rolling stands to the universal ones. For rolling of long and extra-long web I-beams is a new technique needed or welding technique for the production of the a.m. I-beams and long as well extra-long both, web and flanges. I-beams are commonly made of structural steel but may also be formed from aluminium or other materials, although in this paper, only steel-made I-beams technologies will be treated. A common type of I-beam is rolled steel joist (RSJ or INP, namely I-beam normal type, as it is common from German practice and standards). American, British and European standards also specify Universal Beams (UBs) and Universal Columns (UCs). These sections have parallel flanges, as opposed to the varying thickness of RSJ-INP flanges. Parallel flanges are easier to connect to and do away with the need for tapering washers. UCs have equal or near-equal width and depth and are more suited to being oriented vertically to carry axial load, while UBs are significantly deeper than they are wide, and are more suited to carrying a bending load.

The improvements in this field are achieved in Japan, and so rolled I-beams (at the end of 1990-ies) are called NSHYPER BEAMS, but according to the latest achievements, the longest web rolled I-beams (in 2019-2020) are called MEGA NSHYPER BEAMS.

2. CLASSICAL ROLLING COMPARED TO THE IMPROVEMENTS RELATED TO THE I-BEAMS ROLLING

The following standards define the shape and tolerances of I-beam steel sections:
DIN 1025 [1] is a DIN standard that defines the dimensions, masses, and sectional properties of hot rolled I-beams. The standard is divided into 5 parts:

- DIN 1025-1: Hot rolled I-sections - Part 1: Narrow flange I-sections, I-series - Dimensions, masses, sectional properties
- DIN 1025-2: Hot rolled I-beams - Part 2: Wide flange I-beams, IPB-series; dimensions, masses, sectional properties
- DIN 1025-3: Hot rolled I-beams; wide flange I-beams, light pattern, IPBl-series; dimensions, masses, sectional properties
- DIN 1025-4: Hot rolled I-beams; wide flange I-beams heavy pattern, IPBv-series; dimensions, masses, sectional properties
- DIN 1025-5: Hot rolled I-beams; medium flange I-beams, IPE-series; dimensions, masses, sectional properties

Corresponding Euro-norms are:

- EN 10024, Hot rolled taper flange I sections – Tolerances on shape and dimensions.
- EN 10034, Structural steel I and H sections – Tolerances on shape and dimensions.
- EN 10162, Cold rolled steel sections – Technical delivery conditions – Dimensional and cross-sectional tolerances

Other:

- ASTM A6, American Standard Beams [2]
- BS 4-1, British Standard Beams [3]
- AS/NZS 3679.1 – Australia and New Zealand standard [4]
- JIS G 3353 Japan Standard [5]

For rolling of parallel flanged I-beams is needed at least the finishing pass to be performed as the universal pass. Of course, if there are more universal passes, it is better. An example of it is a typical 14-passes roll pass design for rolling parallel flanged I-beams, presented in Fig. 1 [6].
The use of the universal stands is a great technological advance, but they are much more expensive, and it is difficult to incorporate them at the existing (layout) of the rolling mills, where classical roll pass designs are used, presented in Fig. 2 [7]. That is why a variety of the conversions of classical rolling stands to the universal ones is used to get at least one for the finishing pass, or more universal passes, presented in Fig. 3, 4, and 5. [all 8]

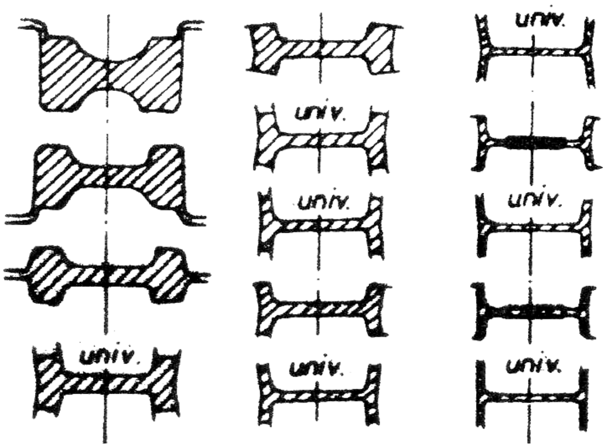

Figure 1. Typical 14-passes roll pass design for rolling parallel flanged I-beams [6]

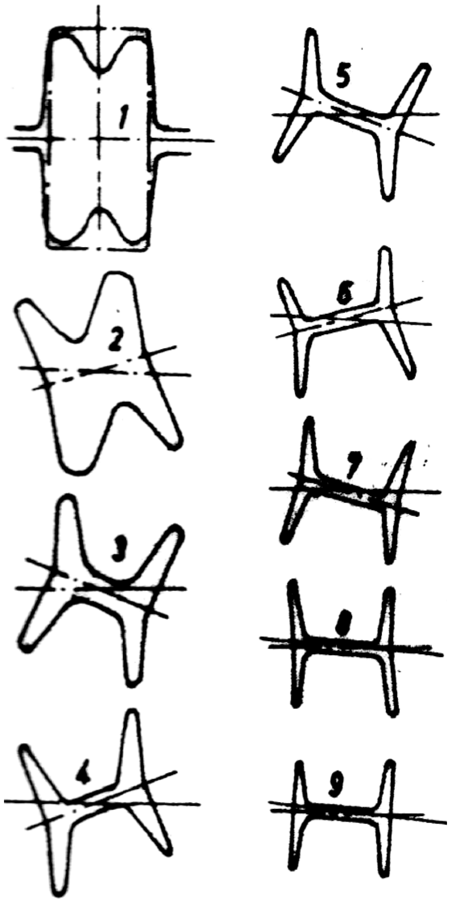

Figure 2. Typical 9-passes roll pass design for rolling INP or W (wide flange) I-beams with tapered flanges [7]

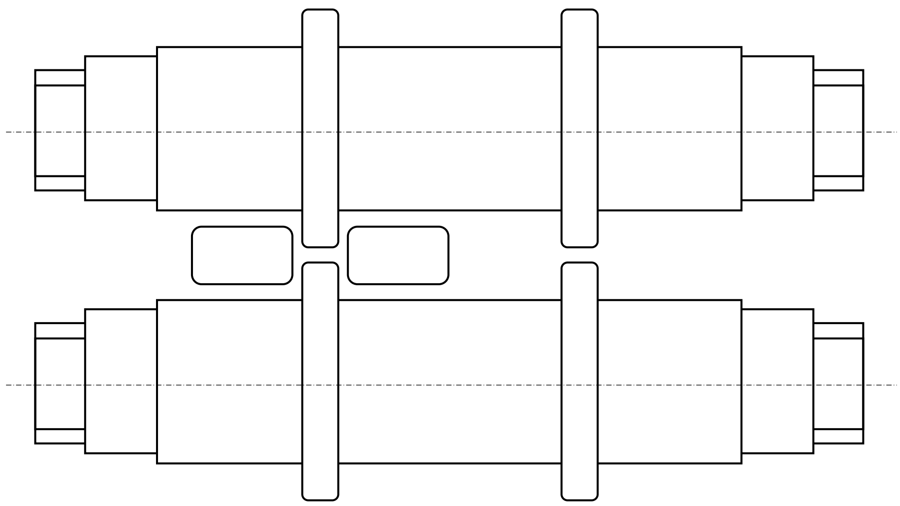

Figure 3. One universal pass at two-high rolling stand [8]

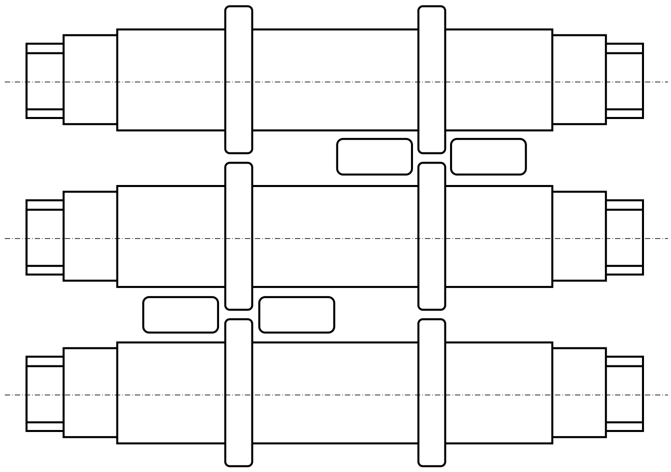

Figure 4. Two universal passes at three-high rolling stand [8]

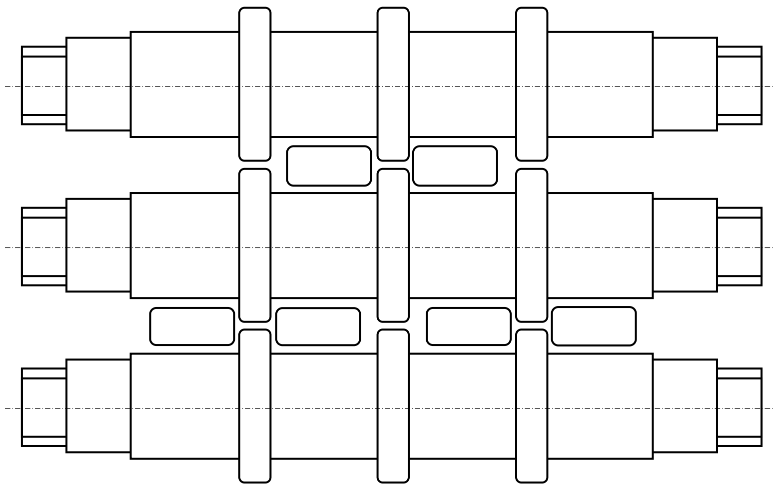

Figure 5. Three universal passes at three-high rolling stand [8]

Because of the difficulties to incorporate a massive and expensive universal stand, in an existing layout of the classical rolling mills, it is easier and less expensive to get one or more universal passes, presented in Fig. 3-5 [all 8]. That is why the improvements related to the parallel flanged I-beams and conversion of the classical to the universal rolling stands were taking so much time and effort [9], although especially in the developing countries, that process still takes place. From 1936 – 1990-ies there were 8 registered patents [8] and now totals more than a dozen [10] in that field, and the first author of this article also had registered its patent application. That patent application is still pending.

According to that, it is possible, under certain pre-conditions, to make a conversion of the classical two-high or three-high rolling stands to the universal ones, and accordingly to get the universal pass/es on them. That is shown in Fig. 3 (one universal pass at two-high rolling stand), Fig. 4 (two universal passes at three-high rolling stand), and Fig 5 (three universal passes at three-high rolling stand). A certain part of the machinery needed for that conversion is presented in Fig. 6 [11] and it is specified accordingly.

This technical solution presented in Fig. 6 converting classical to the universal rolling stand with idle vertical rolls is concerned with a two-high classical rolling stand, having the ratio L/D>or at least equal to (almost 2) 1.8, where L is horizontal roll barrel length, and D is the diameter of the horizontal roll.

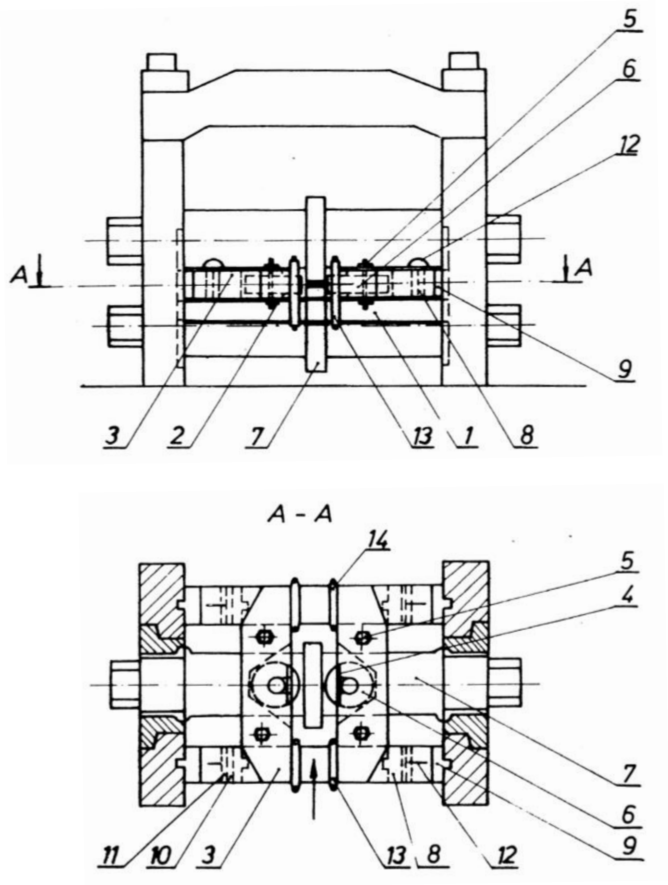

Figure 6. Certain part of the machinery needed for the conversion of the classical rolling stands to the universal ones [11]

The equipment (a part of the machinery) needed for that conversion of a classical two-high rolling stands to the universal ones, according to the symbols in Fig. 6 is consisted of:

1. Bearing beam
2. Lower bearing segment for vertical rolls
3. Upper bearing segment for vertical rolls
4. Bedding and fixing of vertical rolls
5. Bolt for fixing bearing segments 2 and 3
6. Vertical roll (idle)
7. Horizontal roll (driven)
8. Inner support for bearing segments 2 and 3
9. Outer support for bearing segments 2 and 3
10. Base spacer plate
11. Additional spacer plate
12. Grips made of the shaped plate for holding the spacer plates 10 and 11, as well as inner and outer supports
13. Entry guide
14. Delivery guide

3. THE LATEST IMPROVEMENTS RELATED TO THE ROLLING ON THE UNIVERSAL ROLLING STANDS AND PRODUCTION OF PARALLEL FLANGED I-BEAMS

Nippon Steel Corporation at the Sakai mill-Wakayama Works has established a rolling process to manufacture steel beams with depth (web) of up to 1200 mm, which is about 20% greater than its existing large-size beams, and, by expanding the range of structural H-shapes NSHYPER BEAM products, in particular by increasing the

super large sizes using the new brand MEGA NSHYPER BEAM in April 2020. Both a.m. I-beams are presented in Fig.7 [12].
NSHYPER BEAM (1000mm in depth X 400mm in width; left in Fig. 7) and MEGA NSHYPER BEAM (1200mm in depth X 500mm in width; right in Fig. 7) both belong to the latest (new) type (patent protected) rolling technology, presented at Fig. 8 [12], from which is visible that beside vertical (compression – good for metallurgical and mechanical properties) reduction (produced by horizontal rolls), there are horizontal (tension – good for a high spreading or elongation) spreading forces (produced by special horizontal-inclined rolls) and the a.m. rolls produce so-called forced spreading – skewed roll rolling mill – presented at bottom-right of Fig. 8 [12]. That is the explanation of how it is possible, according to the latest technology, to produce a jumbo-web large I-beam (MEGA NSHYPER BEAM).
Such a new (the latest) rolling technology is superior in comparison with new welding technology in I-beams production because the products (I-beams, but also any other rolled products in comparison with the same-similar welded products) are more reliable since there are no inhomogeneities in the material caused by welding.

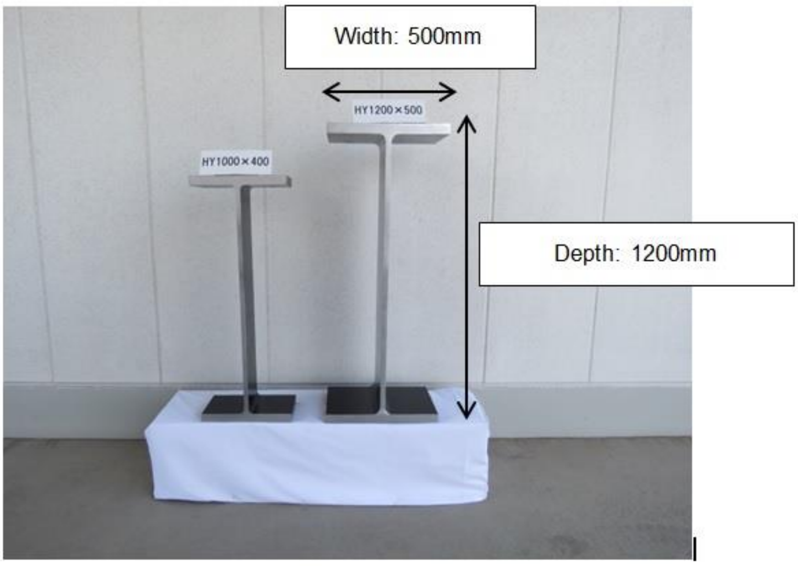

Figure 7. NSHYPER (1000X400mm)-left and MEGANSHYPER BEAM (1200x500 mm)-right [12]

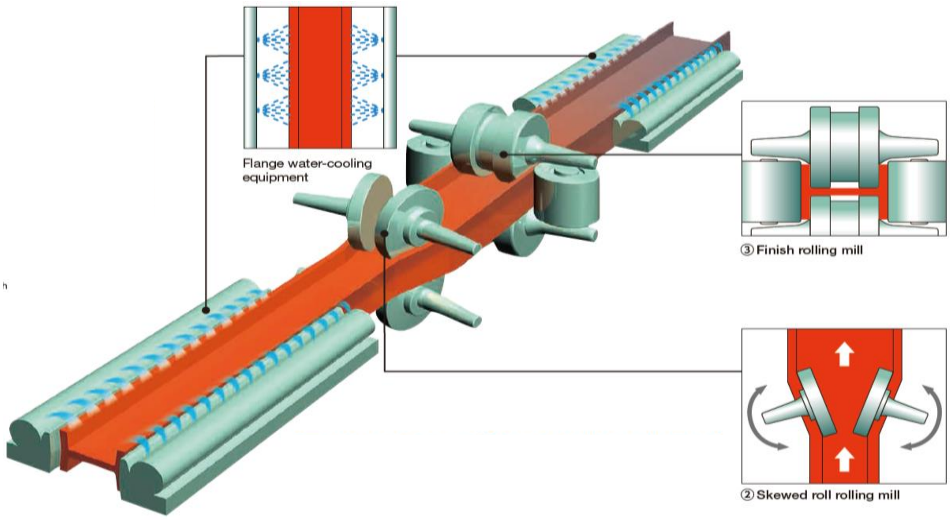

Figure 8. Simple presentation of the rolls positioning for rolling of MEGANSHYPER BEAM (1200x500 mm) [12]

Besides by rolling, parallel flanged I-beams can be produced by welding and it goes for the thin or light-weight type of I-beams (from thin plates), which is presented in Fig. 9 [13]. Very similar technology is used for I-beams production of MEGA-JUMBO sizes in both, the web and flanges, but in that case, thick plates are used. These two technologies are very similar – almost the same ones, but the I-beams produced from thin plates are specified in the standards (since its production according to this technology started some decades ago) and MEGA-JUMBO I-beams produced by this technology is as well standardized, but also could be of a special type, for the bridges and special structures.

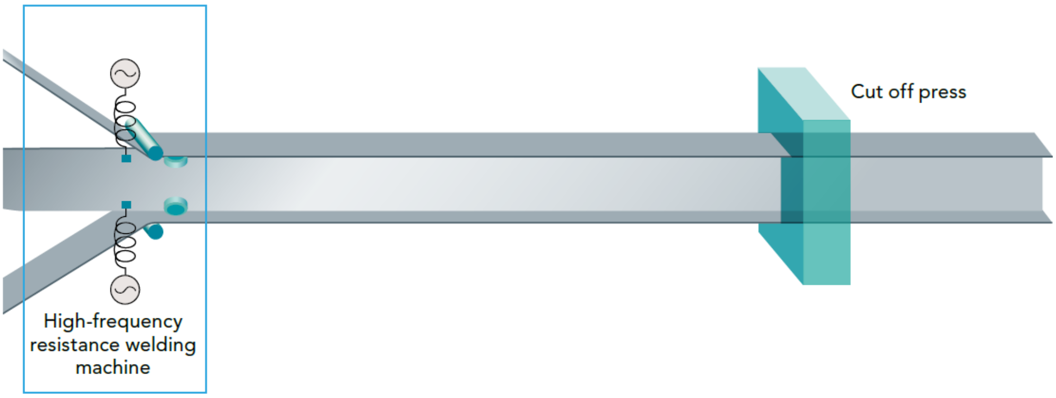

Figure 9. Simple presentation of High-frequency resistance welding technology for I-beams production [13]

4. CONCLUSIONS

Nippon Steel Corporation at the Sakai mill-Wakayama Works has established a rolling process to manufacture steel beams with depth (web) of up to 1200 mm, which is about 20% greater than its existing large-size beams, and, by expanding the range of structural H-shapes NSHYPER BEAM products, in particular by increasing the super large web sizes using the new brand technology MEGA NSHYPER BEAM in April 2020. That is the latest technology in I-beams rolling, comprising a combined use of the universal and forced-spreading passes on the special rolling stands (supplied by special horizontal-inclined rolls for forced-spreading). That invention is very important because rolled I-beams are better (more reliable) than welding-produced I-beams.
The universal passes are necessary for the modern rolling of I-beams, and they can be provided by the universal rolling stands, but also by a conversion of the classical rolling stands to the universal ones. The use of the universal stands is a great technological advance, but they are very expensive, and it is difficult to incorporate them at the existing layout of the classical rolling mills, where classical roll pass designs are used. That is why a variety of the conversions of classical rolling stands to the universal ones is used, to get at least one for the finishing pass, or more universal passes.
Welding technology is also a sort of modern technology to produce I-beams, especially of MEGA-JUMBO size, and the variant of high-frequency resistance welding technology for I-beams production is the state of art in the welding technologies for I-beams production.

Conflicts of Interest:
The authors declare no conflict of interest.

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