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REPAIR OF DRIVING SHAFTS FOR ROLLING MILLS BY WELDING

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ABSTRACT
The procedure of repairing by welding of driving shaft in aluminium rolling mill was considered. The important point was related to the fact that the driving shaft already past certain repairing procedure, with interpass soft material which was inappropriate as it shows a low strength and lack of penetration.
Using filler material with similar chemical composition, may be good solution if important welding procedure factors are fulfilled, like preheating, interpass temperature , cooling rate and post weld heat treatment.
The aim of this to show that using of austenitic filler material as interpass soft metal is often not necessary to use.
Keywords : Repair welding, Rolling mills, Driving shafts, Filler materials, Austenitic structure

1. INTRODUCTION
Driving shafts for Al milling are designed to move rolls for reducing ingots thickness. The milling process is reversible and because of that , driving shafts deal with alternating load and impact.
In this case, driving shaft, was damaged after 15 years of exploitation. Possible reasons are: inappropriate material for coupling changeable elements, so driving shaft was plastically reformatted instead of coupling elements ; the gap between driving shaft and coupling, during exploitation, started to grow, so driving shaft was impact loaded at each change of rolling direction ; inadequately maintained, e.g. without continous contact areas lubrication ; material fatigue ; the groove radius which, in this case, is 6 mm, may be design fault, because it is possible to be up to 95 mm
As mentioned above, the driving shaft was damaged and repaired by welding using two procedures, first based on using austenitic filler material as interpass soft metal and other using similar filler material.
The driving shaft dimensions are given on the figure 1.

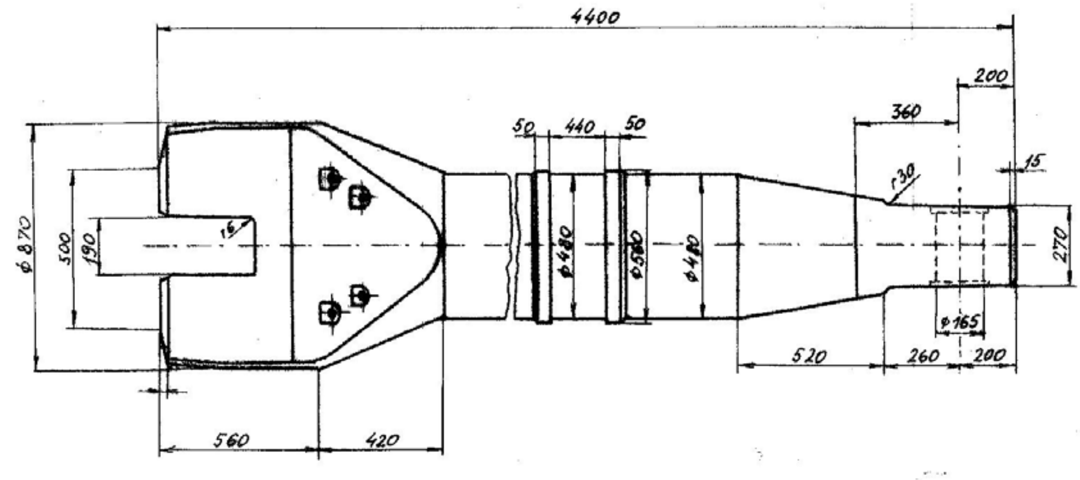


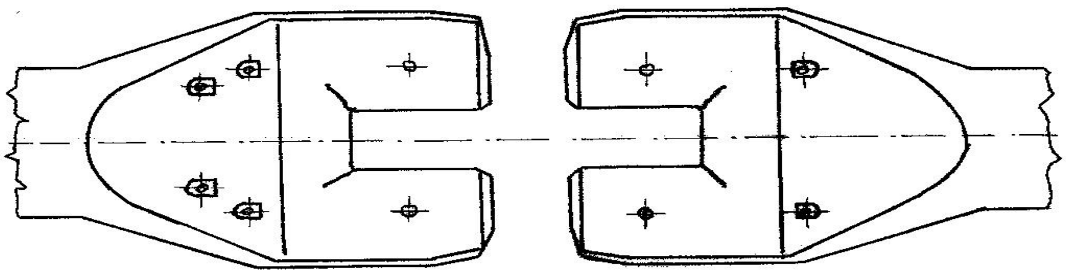
Figure 1. Driving shaft dimensions

2. DAMAGE DESCRIPTIOPN

By visual inspection, magnetic particle and ultrasonic driving shaft damages were as follows :

- mechanical damages on the driving shaftand coupling contact areas on the driving shaft with depth up to 20 mm, extension up to 120 mm and length 200-250mm;
- cracks on driving shaft area with length about 40 mm and depth up to 25 mm.

The cracks locations are presented on the figure 2 - a) front side, b) back side.
The magnetic particle testing replicas are presented on figures 3 and 4.



a) front side b) back side

Figure 2. Crack location

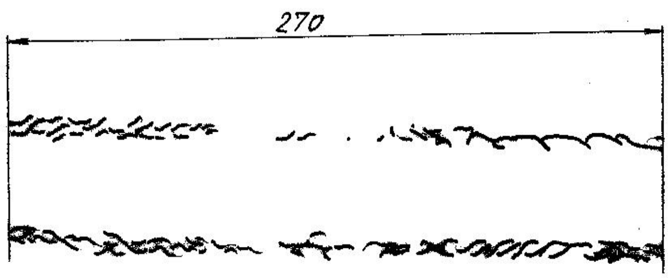


Figure 3. Cracks replica by driving shaft area

Front side

Back side

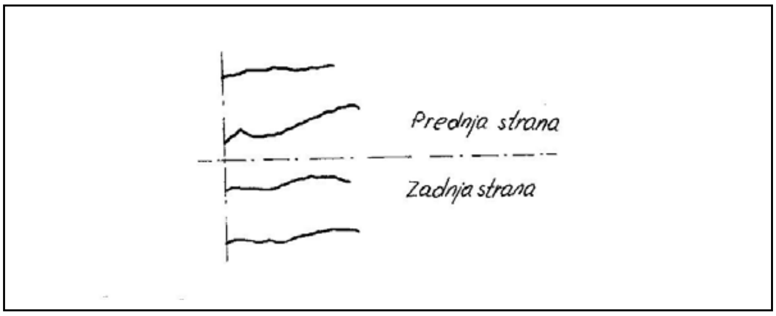


Figure 4. Crack replica by driving shaft groove depth

3. THE DRIVING SHAFT MATERIAL

According to available documentaion, driving shaft are made of 24CrMo5 steel. Chemical analysis was performed and results are given in Table 1. Mechanical properties, acc. to documents data, are given in Table 2.

Table 1. Chemical composition of driving shaft material

Element (%)	C	Si	Cr	Mo	V	S	P
	0,21	0,30	1,07	0,20	0,05	0,014	0,012

Table 2. Mechanical properties of driving shaft material

Yield strength	min. 392 MPa
Tensile strength	588-687 MPa
Elongation	15%
Impact toughness -Scharpy U	min 39 J
Hardness	217 HB

The hardness was checked by Poldy method and values were between 184 -205 HB. It means that driving shaft was heat treated by normalisation or high temperature annealing.

4. REPAIR WELDING PROCEDURE (for austenitic and similar filler material)

The cracks are eliminated by machinig and grinding, so the groove for welding was prepared and presented on the figure 5.

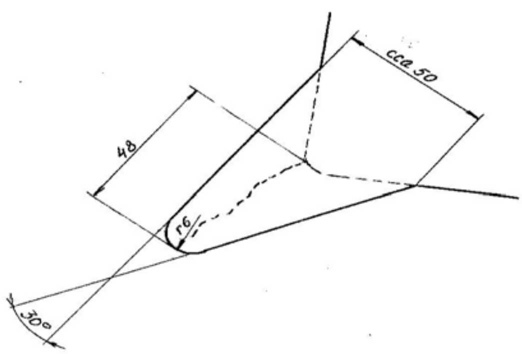


Figure 5. Welding groove sketch

Prehating temperature: 350 ºC. Interpass temperature: 370 ºC. PWHT parameters : - Heating rate from 370 ºC is 50-70 ºC/h, Annealing temperature 650ºC, Cooling rate 50 ºC/h up to 250 ºC, later air cooling.

Welding processes were MMAW for groove welding and MAG with flux cored wire for surfacing driving shaft contact areas.
Surfaced, welded and post weld heat treated driving shaft was inspected by VT, PT, MT, UT and hardness measurement.

4.1. Filler materials

Differences between welding procedures are based only on filler material composition. For first repair, austenitic electrode for first layer on groove sides and for filling, basic coated electrode of carbon steel was used.
The explanation for such choice was :
Austenitic filler material has to give soft layer immediately on fusion zone with aim to dissolve hydrogen and to able plastic deformation start in this part of weld and contact strengthening during driving shaft overloading, without cracking.
This opinion is based on plastic theory and elastic-plastic deformations and soft layer contact strengthening in closed joint. Other filling metal had to give approriate strength and toughness of welded joint and good machinability.
For second repair, similar filler metal amde of Cr-Mo steel was used.

5. CONCLUSION

After first repair**,** driving shaft was exploited few months because the whole welded joint were separated through fusion zone HAZ on austenitic layer.
The lack of penetration was visible like undesribale fault in most welded joints. Also, austenitic weld joint does not have sufficient strength for this type of dynamic loading. Post weld heat treatment in this case was detrimental for welded joint peromance on driving shaft.
Second repair was conducted with identical thermal cycles but with filler metal similar to parent material. The driving shaft, repaired in this way, was exploited more than 10 years.
Beside elastic-plastic theory, it ispossible to conclude that using austenitic filler material in mentioned case is not necessary, specially in drivimg shaft repairing.

6. REFERENCES

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