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OPTIMIZE PRODUCTION DEFECTS IN THE HOT FORGING PROCESS WITH THE INITIAL ROLLING OPERATION.

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Abstract

This research work aims to optimize production defects in the hot forging process with the initial rolling operation. the research on rolling forging operations gives broad scopes of these defects in forging operations such as underfill, cracks formation, and scale pits. rolling operations are usually performed under hot forming conditions depending on the type of motion and shape set-up.

There are different types of rolling processes in which longitudinal rolling forging operation is mostly used in hot and cold rolling forging operations. Which are reduced material consumption in the forging process. That research helps control forging defects with regular correction and preventive analyses in rolling operations.

Keywords- Rolling Operation Edge Crack, Alligator Crack, Under Fill,

Introduction

Rolling is the one of basic processes in forming an operation in which metal flows between two rollers in different directions. The gap between two rollers is always smaller than the billet diameters to be formed. The time of metal piece is put into two rollers roll gets rotated by applying the force of friction and the compression billet gets compressed to thin and elongated than the original length.

Classification of the rolling process.

- According to process.

1. Hot rolling process.
2. Clod rolling process.

➢ According to pass.

1. One pass
2. Two pass
3. Three pass
4. Four passes.

Hot rolling

Hot rolling is a process (fig 01) involving the metal working process carried out when metal is heated above recrystallization temperature. These are considered most large-size products in which the material grain deformation maintains a microstructure that prevents the metal work hardening. Before rolling operation billet is processed and heated to a high temperature before feeding into rollers most above room temperature and get rolled. [1]

The heating process before rolling may lead to the deterioration of tensile properties in the thickness direction.

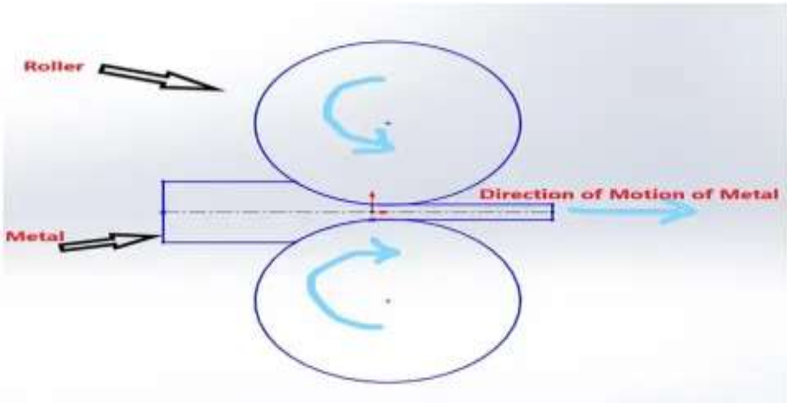

Fig.01 Hot rolling process.

Roll design parameters

Rolling operation before that considering some roll parameters for calculation such as.

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1. **Rolling draft**. – Is the work parts of a rectangular cross-section in which the width is greater than the thickness. In a flat rolling operation, the work is rolled between two rolls so that its thickness is reduced by an amount called the draft. [2]

$$d = h_o - h_f \quad = 2R(1-\cos\gamma)$$

where

d = draft mm

h_o = Starting thickness mm

h_f = final thickness mm

R= radius mm

γ= bite angle in degree.

2. **Thickness Reduction or spreading**

Spreading is the operation in which thickness reduction, and rolling usually increase work width this is called spreading. It tends to be most pronounced with low width-to-thickness ratios and low coefficients of friction, so the volume of metal exiting the rolls equals the volume entering.

$$h_o W_o L_o = h_f W_f \ L_f$$

Where

wo and wf = are the before and after work widths, mm (in);

Lo and Lf = are the before and after work lengths, mm (in).

3. Volume rates of Material flow volume rates of material flow must be the same, so the before and after velocities can be related:

$$h_o w_o v_o = h_f w_f \ v_f$$

Where

vo = entering velocity

vf = exiting velocities of the work.

Vr =The surface speed of the rolls.

the velocity of the strip increases from its entry value of VO as it moves through the roll gap; the velocity of the strip is highest at the exit from the roll gap and is denoted as Vf

4. **Rolling Load**

Rolling load depends on roll diameters higher rolling diameters get higher roll force, smaller roll force smaller diameter of roll. So rolling forces depend on roll diameters.

$$\lambda = a/L_p = a/\sqrt{R \cdot \Delta t}$$

Where

λ= 0.5 for hot and 0.45 for cold.

a = moment of arm in mm

R= radius of billet in mm.

Since there are two work rolls involved, the work done is equal to

Work done =2 (2.π.a).

P = 4P.π.a

If N is the speed of rotation of the rolls then Power =

Work done/sec= 4P.π.a.N/60

Ie.

Power= (4P.π.a.N/60x1000) Kw

Where P=Load in Newton,

a=moment arm in meters

N=speed rollers This gives the power required for the deformation of metal only.

Defects in Rolled Products- In rolling operation two types of defects are found those affect to forging process. **[5]**

a) General

b) Operational

a) General

The defects may arise due to

i. **Surface irregularities**:

In rolling operation, the ingot or the raw material may produce surface irregularities due to scaling which gets rolled in two rolls, and due to the surfaces of metal getting lap to each other and surface getting defective. [3]

So needs to be removed by such defects Once more operations are performed on such products it will grind and there will be metal loss. If the defect is deep and severe the product may get rejected.

ii) **Non-metallic inclusions**:

In steel material get composition of material oxides or nitrides or silicates are present etc. These are present in the molten stage metal during the preparation. If the percentage of composition gets less in material small cracks in the metal and if more in volume will result in severe cracks called crocodile cracks separating the product into two halves.

iii) **Internal Pores:**

Due to the presence of gases like hydrogen, oxygen, nitrogen, etc. in the product at the time of the rolling process at the time of elongation, much gas gets produced affecting the product to get weaker sometimes resulting in cracks developing.

iv) **Barrel:**

Sometimes in the rolling process barrel action takes place on the surface of products. Barrel defects are carried on the center of the product center tends to expand laterally more than the outer surface in contact with dies and produces barreled edges.

v) **Non-uniform deformation**:

When the rolling process middle portion is less deformed as compared to outer surface conditions is called nonuniform deformation. Such defects carry in the rolling process due to variations in temperature in the metal. The surface temperature is more than the inside temperature of the slab.

vi) **Alligator Cracks:**

Most of them crack occur due to metallurgical weakness in the metal. In rolling operation, the material gets fractured center line of material that crack formation is called alligator cracks.

Defects: Operational

i) Waviness. Varying thickness.

ii) Edge Cracking

i) **Waviness. Varying thickness**.

The Variation in the work across due to the gap is not perfectly parallel (a) and not maintaining proper rolling between two rolls. So gap between two rolls are important factor in the rolling process.

ii) Edge Cracking

The length of the center portion increases but the edges are prevented due to frictional force.

As a result, the material gets rounded off (a). [4] The edges are strained in tension leading to edge cracking along the width of the slab (b).

When the difference in the strains becomes excess i.e. under severe conditions, a split at the center of the slab occurs (c).

Fig 02 Crack Barrel fig 03 Alligator Crack

Fig 04 Folding Crack Fig 05 Non-Uniform Deformation Crack

Experimental setup

The main aim that resurrected was to find out crack formation in the forging process and control. Such types of cracks by preventive and regular corrective action on that process. Also considering the other defects carried in forging operations such as underfill etc. Fig 07 analyses of forging operation step by step and finds the maximum srcape-producing operation in forging operation with monthly and yearly scrab reports.

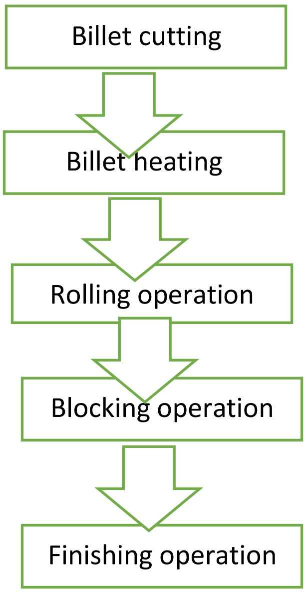

Fig 07 Operation considering for work.

In that paper analyses of operation with scrap report on month basic and find out maximum production scrap will get which operation. Scrap of product observed by various defects in forging operation such as. [6]

- Rolling process
- Upsetting operation
- Blocking operation
- Bur lap
- Under fill
- Crack

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These are the main operational process defects in the forging operation that affect on forging production rate. In which rolling process underfill, burlap, material folding, and crack types of defects are produced in rolling operation. Table 01 shows the monthly scrape report having different types of products. Fig08 shows the monthly scrape report graphical presentation of production in all months in different shifts.

All products have different sizes and shapes. All products require a rolling operation to increase length and divide the material into required dimensions (gathering the material as per shape.) in rolling operation in which dividing the material are by using the rolling path.

Table 01 Monthly scrap report of products

	Monthly Scrap Report													
Sr. No.	Die No.	Heat Code	R. R.	Upset	BLK	Fin	Bur Laps	Under fill	crack	Final Insp. Miss/M	Other	Total Scrap	Ok Job Qty	Scrap Percent (%)
1	103	BE	1	0	2	0	0	6	35	0	0	44	1,648	2.60%
2	104	BD	0	0	0	0	0	0	0	0	0	0	2,998	0.00%
3	105	AG/AK	6	1	6	15	0	23	0	22	0	73	1,604	4.35%
4	106	AI/AL	0	10	7	25	8	87	4	16	0	157	8,220	1.87%
5	115	AK 5	0	2	1	1	0	1	0	0	2	7	1,177	0.59%
6	118	D2-2/D2-3	0	0	2	34	0	0	0	0	0	36	3,376	1.06%
7	117	C2-1	0	0	0	0	0	0	0	0	0	0	1,605	0.00%
8	128	F5-1	0	0	1	5	0	3	0	6	0	15	4,425	0.34%
Total :-			7	13	19	80	8	120	39	44	2	332	25053	1.31%
Scrap Percent (%)			2.11 %	3.92 %	5.72 %	24.10%	2.41 %	36.14 %	11.75%	13.25 %	0.60 %			

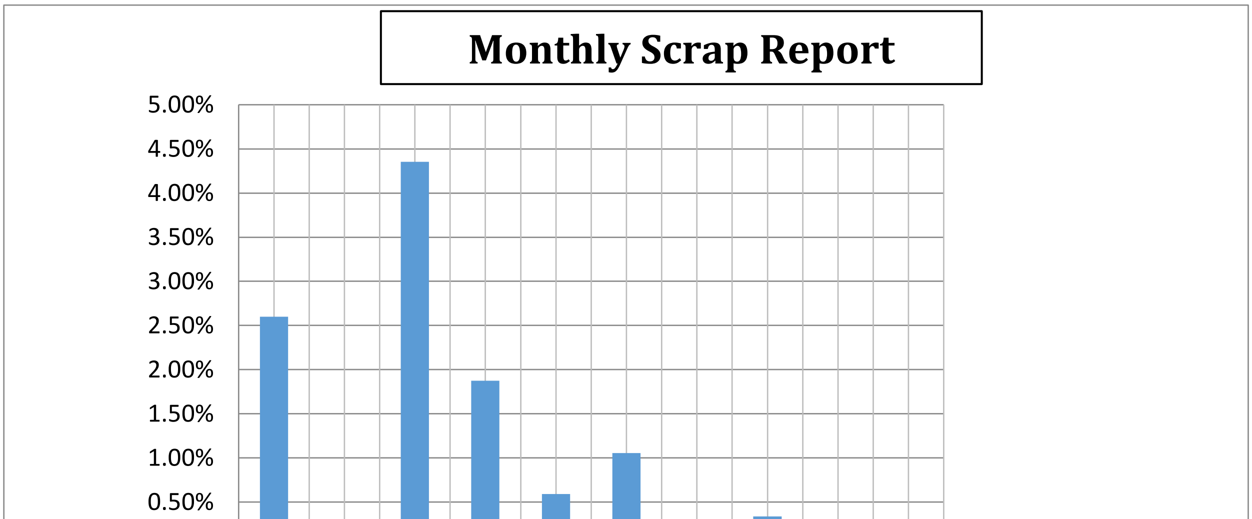

Fig 08 monthly Scrap report.

Table 02 Yearly Scrap Report

Sr. No.	Die No.	R. R.	Upset	BLK	Fin	Trimming	Under fill	crack	Final Insp.	Other	Total Scrap	Ok Job Sty	Scrap Percent (%)
1	101	0	8	40	49	0	63	298	0	11	469	17994	2.54%
2	102	615	1	453	533	1	2799	0	18	4	4424	208816	2.07%
3	103	6	2	16	3	0	70	87	0	3	187	492	27.54%
4	104	0	8	17	8	0	3	0	0	0	36	9957	0.36%
5	105	4	0	5	8	0	6	0	0	0	23	100	18.70%
6	106	13	0	8	9	0	22	0	0	0	52	100	34.21%
7	107	0	4	14	3	0	10	8	0	0	39	1996	1.92%
8	108	28	0	83	100	0	493	1	0	44	749	31403	2.33%
9	112	0	0	2	6	0	1	0	0	0	0	0	0.00%
Total		**666**	**23**	**638**	**719**	**1**	**3467**	**394**	**18**	**62**	**5979**	**270858**	**2.16%**
Total Scrap Percent (%)		**11.14%**	**0.38%**	**10.67%**	**12.03%**	**0.02%**	**57.99%**	**6.59%**	**0.30%**	**1.04%**			

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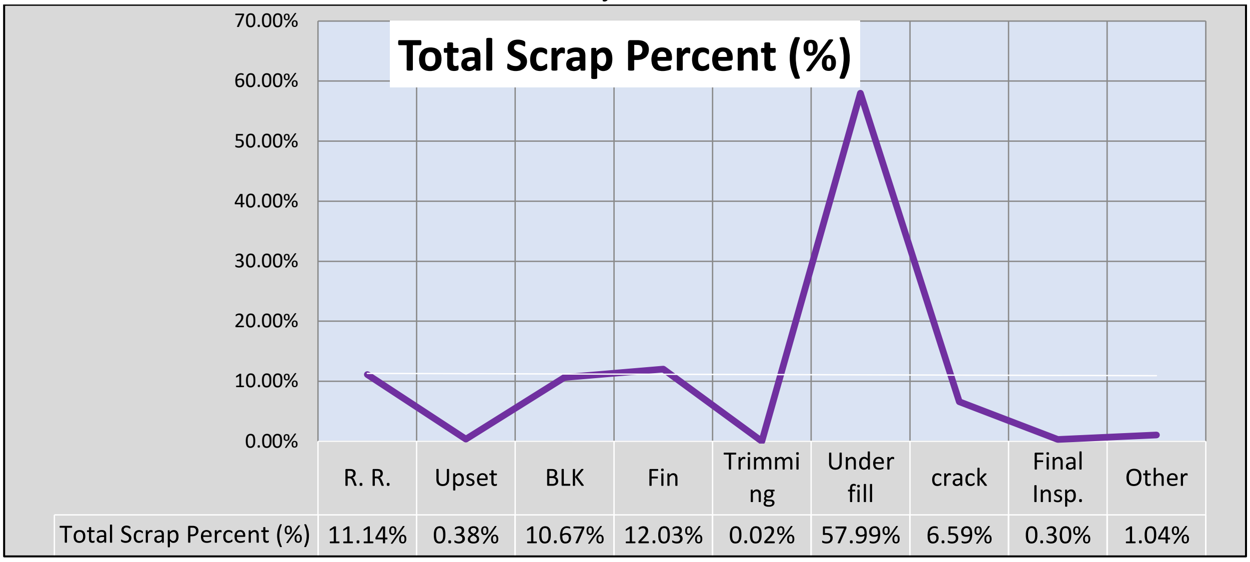

Fig 09 Operational scrap analyses

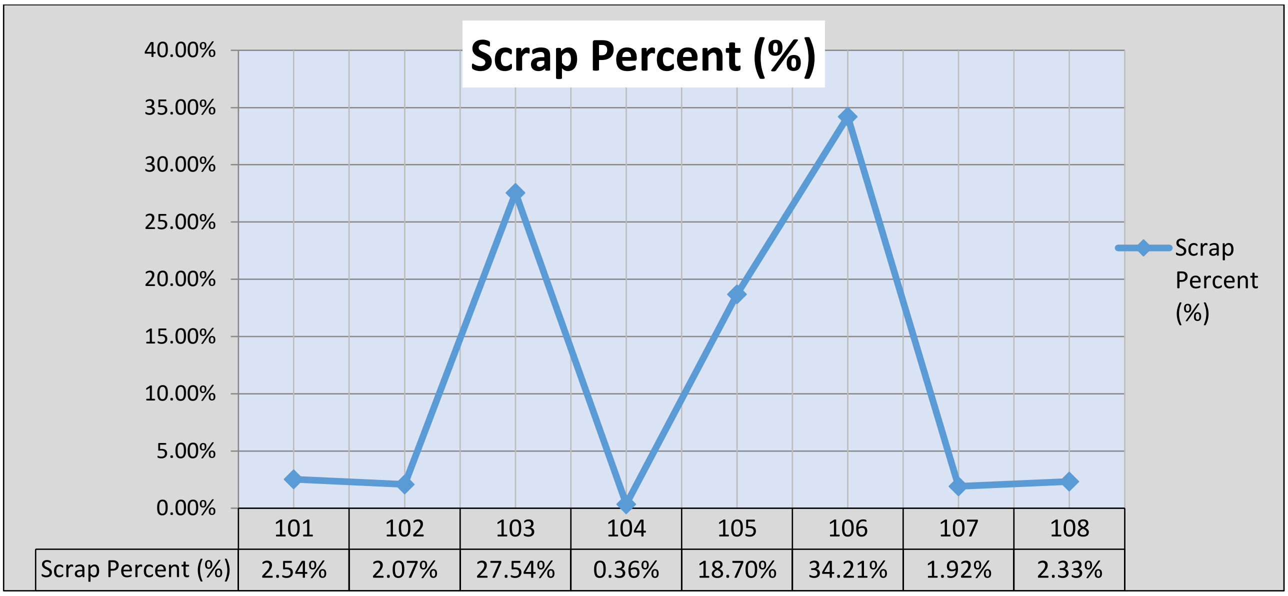

Fig 10 percentage scrap in products

After analyses of both report we conclude that in maximum production scrape are from that crack formation under fill of job and in rolling process scrap are carry.

In rolling operation experimental analyses.

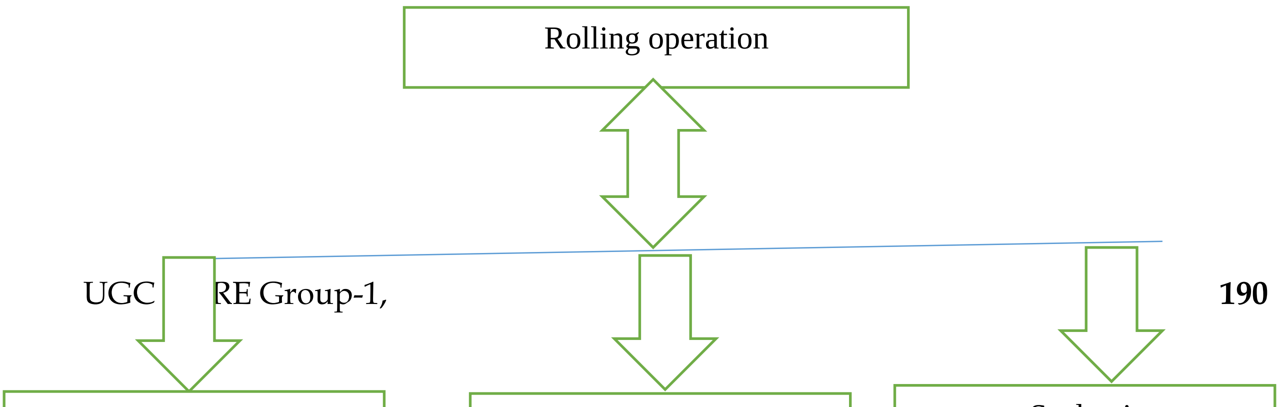

Fig 11 Showing Defects Carry in Rolling Operation.

1. **Crack formation**

   In rolling operation different types of crack are to be from due different region that will get analyses in that point.

   Types of crack

   1. Folding crack
   2. Alligator crack
   3. Edge crack

Folding crack formation.

- That crack formation is done due to proper rolling operation done by the worker.
- Folding crack formation is due to scale pit lapping in rolling operation.
- Folding crack formation due to gap not maintained in the proper size of billet.
- Folding cracks are due to proper heating of the material.

Due to that folding crack formation material gets reworked by applying the grinding process on that job. But for grinding operation material gets weak and fractures.

Alligator crack formation.

- This crack formation in rolling operation is due to proper heating of the job.
- Alligator crack is the metallurgical effect of material for producing gas in rolling operation.
- Alligator crack is carried due to uneven forces applied on the rolling process by the operator.

The effects of that crack material cannot be reworked they get fractured or scraped. That crack gets found after the MPI system so that in are last stage of inspection of the forging process that crack has maximum depth.

Edge crack formation.

- Edge crack formed at the edge of the job due to uneven heating of the job.
- Edge crack formed due to operator pushing force condition job in the rolling path.
- Edge crack formed due to quenching methods of material at the time of rolling operation for maintaining a temperature of billet.

Edge crack gets rework type of crack it will be found in process operational work. but edge crack which will occur due to the quenching process that is not reworked they gate find out after MPI methods.

Underfill formation.

- Underfill defects carry due to in proper elongation of material in rolling operation.
- Under fill defects are carried due to proper gathering of material in the rolling operation.
- Underfill defects are carried due to in proper location of the job in blocking and finishing operation.
- Underfill defects are carried out due to improper cutting of billet size by the shearing machine.
- Underfill defects are carried by in-process temperature variation and in proper heating of the job.

This type of defect only controls they may be reworked. Such defects are found in process operation checking.

Scale pit formation.

- Scale pit formation are carry only de-oxidation of material due to heating process.
- Scale pit defects are occurring in rolling. Blocking finishing operation also.

This type of defects only control by using spraying the air for removing the scale pit which form in operation.

Rolling defects controlling process

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Corrective action to control rolling defects.

In rolling operation generally, all times of cracks are to be controlled by applying some preventive and in-process action such as.

- Folding crack can be controlled by the mantling heating process which carries in the induction heating process mentioned in the process chart according to the heat coding of the job.
- At the time of the rolling operation spraying the pressure air on the rolling pass helps to remove the scale pit on the rolling path.
- Proper quenching of the material changes the quenching media by replacement of air.
- The scale pit is also controlled with a regular grinding operation which helps to remove built-up edge formation and uneven surface formation on the rolling surfaces.
- Due to the grinding process which also removes the serration mark on a rolling path controls the zipper crack formation in the rolling operation.
- To matinee the proper gap in between to roll which controls edge crack and underfill defects, gap factor controlling the elongation of material.
- Gap in between two roll controlling dividing material of job, that effect on crack formation by uneven surface formation in rolling operation.

Crack found after MPI system.

Fig 12 Crack Formation Job for Overheating and Rolling Operation.

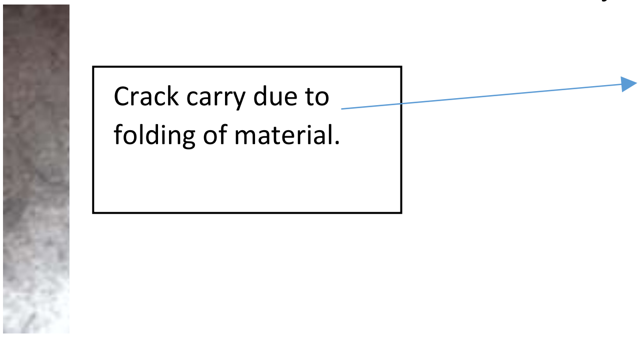

Fig 13 Crack Due to Folding Material.

Above fig.11 and Fig. 12 all types of cracks are found in the forging process operation in MPI operation that operation carrying forging process at the final stage of inspection. In that inspection method analyses the crack depth.

Conclusion

In that paper, we find out the total scrap in the forging process which are found out on a monthly and yearly base. Maximum scrap carried in the forging process due to under fill of the job and crack formation in the job. All forging defects get analyzed for forging operational step and analyses all operations. We find that 80 % of defects in forging process scrap are related to rolling operation.

In that paper, we find which types of defects gat formed due to rolling operation and their region of formation more crack formation defects are carried due to the rolling operation process which is analyzed and all get controlled by taking some corrective action on that rolling are explained in the paper, for controlling such crack formation defects.

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