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Analysis Of Existing Rolling Mill With Prototype Soft Starting Arrangement Of Rolling Mill For Energy Conservation – An Experimental Approach

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Abstract

In this paper an analysis is done on the main drive of rolling mill which consumes about 60 to 70 % of total energy of the plant. The existing rolling mill in India are using the 3 phase induction motor and flywheel to drive the rolling mill. The electric motor transmits the power to flywheel with the help of V-belt. An attempt has made after analysis of existing mill that by using some soft starting arrangement, which can be use as a clutch in between the motor and flywheel reduces the horse power of main drive which save the energy consumption of rolling mill. The optimum selection of drive can help in reducing the horse power of main electric motor and at the same time capable of energies the flywheel. An experimental analysis is done by using flat belt drive and motor sliding arrangement in order to reduce the H.P. of main electric motor.

In this paper an attempt has made after analyzing the existing rolling that a mechanical soft starting arrangement is designed and tested on prototype rolling mill. The soft starting arrangement used in this protype rolling mill analysed and concluded that in the actual rolling mill the motor used are oversized which consumes the more energy. By designing the soft starting arrangement , the motor horse power can be reduced which ultimately saves the energy consumed and hence the billing cost can be reduced.

1. INTRODUCTION

Rolling mill are mainly dependent on the electrical energy and about 60 to 70% of electrical energy is spent on rolling operation and balance is consumed on auxiliary operation like cutting of roll stock, furnace blower ,crane operation etc. The increasing cost of electrical energy made it essential for steel rolling mills in India to consider the electrical power requirement seriously. In a rolling mill, electrical power contributes major part in the cost of rolling.

Our country produces about 40 million tons of steel, out of which 50% is produced by small scale steel three high rolling mills. An average of about 400 crore units of electricity which is consumed in rolling steel bars hence there is a great scope for considerable saving in electricity by proper design of prime movers for the rolling mills. Energy conservation studies of these mills have shown that oversized prime movers causes excessive wastage of energy therefore the prime movers have to be designed to save the energy.

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As per the literature available regarding the consumption of power during the rolling of any product, all are based on rolling industries situated in foreign countries. In such countries the rolling process is continuous one but in India we have most of the rolling mills as open train rolling mills. In these rolling mills the energy As far as the literature available regarding consumption of power during rolling of any product, all are based on consumption pattern is different from them and no one has attempted to go through the systematic analysis and study of this subject as it is a boundary case of mechanical, electrical, and metallurgical engineering.

It has been proved by the researchers that in running condition of the rolling mill the consumption of energy required is low as compared to starting of the mill. The motor is to start the flywheel from initial condition to full speed and largest size of flywheels are frequently recommended for smooth running of rolling mills at the same time they tend to decrease the size of the motor. The main difficulty encountered in selecting large capacity flywheel or flywheel gear box system is the starting of the mill with smaller capacity electric motor. The starting characteristic of electric motor is not suitable for starting such rolling mill with very high inertia flywheel. Hence there is tendency to use high horse power motor which is capable to start the flywheel initially. In such condition it becomes very essential to introduces the soft starting

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arrangement for the electric motor so that considerably small size motor can start the flywheel effectively.

2. SURVEY OF OPEN-TRAIN ROLLING MILLS IN RAIPUR REGION (C.G.) INDIA

The open-train rolling mills are commonly employed for the production of rolled sections like rods, bars, angles, flats etc. These rolling mills are from 150 to 275 mm three high six stands mills. The normal sizes of electric motors ranges from 400 H.P. to 1000 H.P. the rolling speed ranges from 2.25 m/sec. to 3.5 m/sec.

The normal size of ingot is 90x90 mm and overall production per hour depends on the section being rolled. It is observed that an average 80 to 120 pieces can be produced per hour, independent of the section size. Hence, the maximum attainable production is from 500kg/hour to 4.5 tones /hour. The electrical motors are designed to meet any change in the section size from 6 mm bar to 75x75x6 angle.

We have observed the weekly/monthly production records of the rolling mills showing the production in tones and the energy consumption during these periods. Also, the approximate product mixes (if various sections are rolled) are recorded. On the basis of tonnage and other records, energy consumption per tonne for each section was estimated. About 25% of the energy is assumed to be consumed for operations other than rolling (this assumption is also backed by the experimental results of Russian Scientist, Gipromez instt.data.)

3. CASE STUDY OF U.P. ROLLING MILL

we have selected one of the renowned Hot Rolling Mill "U.P. ROLLING MILL" situated at Industrial area of URLA, RAIPUR(C.G.) INDIA. The total area of the plant is 10 acres whereas the layout area of the plant is 1.5 acres. The gross production of the plant is 100 tones /day. The raw material used about 120 tones /day & storage raw material is about 200 tones /day. Some important data related to our analysis are as follows.

Table No.1

Sr. No.	**Particular**	**Specifications**
1	Raw material	Mild steel
2	Product size	254 - 305 mm
3	Motor power	746 K w
4	RPM of motor	720rpm
4	Flywheel weight	10000 kg
5	Size of V belt	E-418mm
6	Diameter of shaft	204 mm
7	Diameter of big pulley	1727 mm
8	Diameter of small pulley	610 mm
9	RPM of flywheel pulley	254rpm
10	RPM of reduction gear	140rpm

Some of the photographs taken from the mill.


Fig. 1 RAW MATERIAL **Fig. 2 FURNACE**


Fig. 3 PULLEY **Fig. 4 FLYWHEEL**


Fig. 5 FLYWHEEL ARRANGEMENT Fig. 6 OUTPUT

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4. ANALYSIS OF DATA TAKEN FROM ROLLING MILLS

We have use the non contact type electronic digital tachometer for the purpose of analysis of rpm of motor and the flywheel from the initial condition to the maximum rpm of the flywheel and same is recorded by using the video camera. The above set up is done in the rolling mill fig. no. 7,8 9 and the reading is given in table no.2 below.

Fig. 7 SETTING THE EQUIPMENTS AT INTIAL CONDITION

Fig. 8 TECHOMETER READING Fig. 9 VIDEO RECORDING

Table No.2

TIME (SEC.)	MOTOR RPM	FLYWHEEL RPM
0-1	751.2	0
2	744.9	67
4	669.6	84
6	654	122
8	676.8	165.3
10	649.2	179.5
12	615.9	191.1
14	599.7	200.6
16	591.1	207.8
18	583.9	213.7
20	579.5	217.7
22	574.2	221.4
24	569.8	223.6
26	561.5	223.8
28	554.6	225.5
30	542.4	226.8
32	535.7	228
34	529.2	229
36	492.1	232.8
38	485.9	232.3
40	479.2	244
42	471.8	244.3
44	460	244.1
46	479.2	244
48	488.2	244
50	495.4	243.9
52	511.2	244.1
54	526.9	244
56	536.8	243.9
58	545.1	243.7
60	555.3	243.7
62	586.9	244.1
64	606.4	243.5
66	625.9	244.3
68	647	244.1

70	667.2	244.2
72	680	244
74	702.3	244
76	723.6	244.2
78	734.4	244
80	745.6	244.1
82	752.9	244.1
84	756.4	244.1
86	756.5	244
88	755.7	244.2
90	753.3	244.3

Based on the above reading from table no.2 , the graph is plotted in between the r.p.m. of the motor along the Y axis and the time in seconds along the X axis. The result of the graph is given in the fig . no.10.

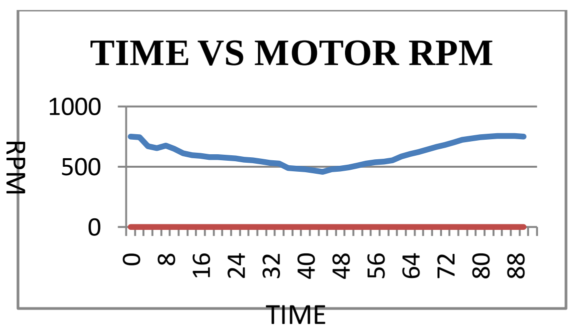

Fig. 10 GRAPH OF TIME Vs MOTOR R.P.M.

From the table no.2 , a graph is plotted between the flywheel r.p.m. on Y axis against the time in seconds along X axis and the result of the graph is shown in fig .no.11

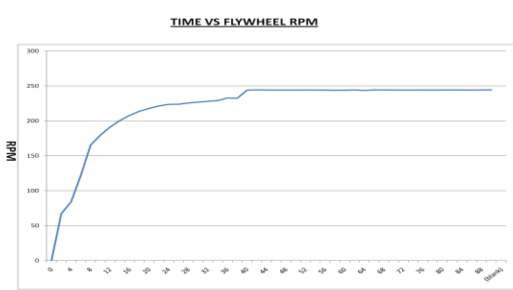

Fig. 11 GRAPH OF TIME Vs FLYWHEEL R.P.M.

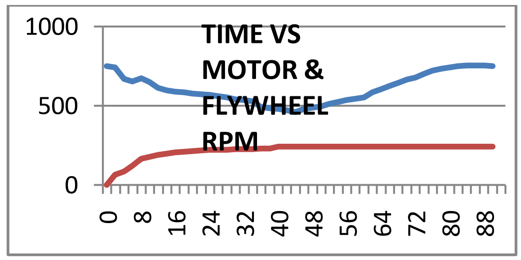

Fig. 12 GRAPH OF TIME Vs MOTOR R.P.M.

From the fig. no. 10 and 11 , we have plotted a third cumulative graph shown in fig . no. 12 .As we can observe from the fig. no.12 that in the initial situation the motor rotates at its full speed and the flywheel is at the stationary condition for the time period of 0-2 seconds . Then slowly the motor rpm decreases with there is an increase in flywheel rpm. After that there is a continuous decrease in motor rpm as well as there is an increase in flywheel rpm as the motor is supplying the energy to the flywheel and after 44 seconds the flywheel rpm become constant and the motor r.p.m. is increasing as the flywheel attains the maximum speed and now motor tends to attains the maximum speed. After 84 seconds both motor and runs at constant maximum speed.

We have also observe that there is no change of voltage at any stage either in no load or load conditions. The voltage is constant (420 V). But there is sudden fluctuation in current from 800amp to 1400 amp of the motor , which shows that when motor runs at no load condition then the current drawn by the motor is about 800 amp. and when whenever the load comes to the mill the motor draws the higher current up to 1100 amp. depending upon the temperature of the ingots. When the temperature of the ingots is low, the motor draws the higher amp. up to1400 amp. This due to the reason of motor tends to regain the r.p.m. and torque very fast and it draws the higher current.

5. EQUIPMENT SETUP

Based on the study of hot rolling mill in the Raipur region and since for the experimental analysis we have developed a prototype rolling mill model. In the equipment we have neglected the rolling action due to the reason that it has been proved that in running condition the power consumed by the electric motor is less as compare to in the starting period. So the main focus area for the energy conservation is in starting of the mill. In the initial condition the motor should be capable enough to drive the flywheel at maximum speed. Hence our focus area is electric motor and flywheel.

Fig. 13 PROTOTYPE MODEL

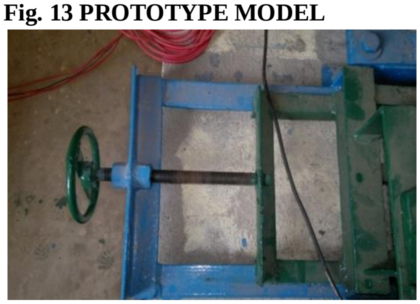

Fig. 14 SLIDING ARRANGEMENT OF MOTOR

We have designed a flat belt which replaces the existing V-belt drive in the rolling mill, due to the fact that flat belt allows the slip up to 3% and comes into the category of flexible drives. This can act as a clutch in rolling mill by inserting a sliding frame arrangement in the equipment fig.no.12.In the initial condition the frame is moved towards the flywheel so that the belt becomes loose and the motor runs at no load condition as the motor attains the maximum speed the frame moves slowly away from the flywheel ,due to this the belt becomes slightly tight and motor try to rotate the flywheel. By using this type of arrangement the load does not comes directly on to the motor and it act as a soft start. The frame again moves away from the flywheel at constant rate till the belt becomes full tight.

The following table gives a brief idea regarding the comparison of existing rolling mill and our equipment setup-

Table No.3

Sr. no.	Particular	Data from industry	Our equipment data	Ratio of both the data
1)	Motor H.P	1000	0.5	1:2000
2)	Weight of flywheel	10000 kg	57 kg	1:175
3)	Size of flywheel	10 m	0.5 m	1:20
4)	Maximum motor RPM	760	1440	1:0.52
5)	Maximum flywheel RPM	240	960	1:0.25

From the table no.3 , it is clear that we have use very less horse power motor which 2000 times lesser than the motor used in the actual rolling mill where as the flywheel used for this purpose is 175 times lesser than the actual ones. The motor is capable of rotating flywheel with using sliding frame arrangement and also without using the arrangement also which is experimentally proved. This shows that in actual rolling mill the motor used for the rolling are oversized. The common policy used in the rolling mill is to use the oversized motor which increases the billing cost of the plant. By using any one type of such arrangement, the billing cost of main electric motor which is about 60% of power consumption can be reduced.

6. ANALYSIS OF PROTOTYPE SOFT STARTING ARRANGEMENT OF ROLLING MILL

We have use the non contact type electronic digital tachometer which is fixed on to the panel of the set up. From initial condition to the final condition , all the readings are recorded by using the video camera and the reading are then split in to the time duration of 2 seconds. The readings of experimental set up is displayed in figure no. 15 to 18 and all the reading are given in the table no. 4

Fig. 15 INTIAL READING

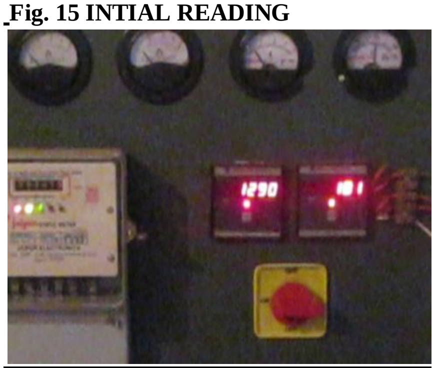

Fig. 16 READING AFTER 9 SECONDS

Fig. 17 READING AFTER 47 SECONDS

Fig. 18 READING AFTER 90 SECONDS

Table No.4

TIME (SEC.)	MOTOR RPM	FLYWHEEL RPM	TIME in (SEC.)	MOTOR RPM	FLYWHEEL RPM
0-2	1462	0	46	1341	767
2	1465	0	48	1351	783
4	1397	45	50	1352	804
6	1394	135	52	1354	823
8	1366	178	54	1355	869
10	1367	215	56	1372	896
12	1379	247	58	1399	922
14	1386	274	60	1412	932
16	1351	300	62	1421	943
18	1338	331	64	1429	949
20	1325	361	66	1421	951
22	1343	392	68	1432	954
24	1274	420	70	1433	958
26	1291	453	72	1433	958
28	1283	512	74	1433	958
30	1279	534	76	1433	958
32	1273	554	78	1433	958
34	1303	574	80	1433	958
36	1305	627	82	1433	958
38	1332	664	84	1433	958
40	1335	690	86	1433	958
42	1340	709	88	1433	958
44	1341	738	90	1433	958

As we can see from the table no.4 that in the initial condition the motor rotates at its full speed and the flywheel is at the stationary condition. Then slowly the motor rpm decreases with there is an increase in flywheel rpm. After that there is a continuous decrease in motor rpm as well as there is an increase in flywheel rpm. Finally after 68 seconds both the motor and flywheel rpm become constant.

Based on the table no. 4 , we have plotted the graphs fig. no. 19 shows the motor r.p.m. vs. time in seconds. From the graph no. 19 , it is clear that the motor r.p.m. decreases with respect to time and after 68 seconds it is almost constant.

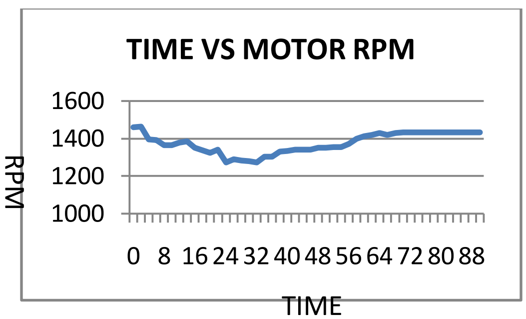

Fig. 19 GRAPH OF TIME Vs MOTOR R.P.M.

From the readings from the table no. 4 , we have plotted the graphs fig. no. 20which shows the flywheel r.p.m. vs. time in seconds. The graph shows that the flywheel r.p.m. increases at constant rate with respect to the time and after 68 seconds it is almost constant.

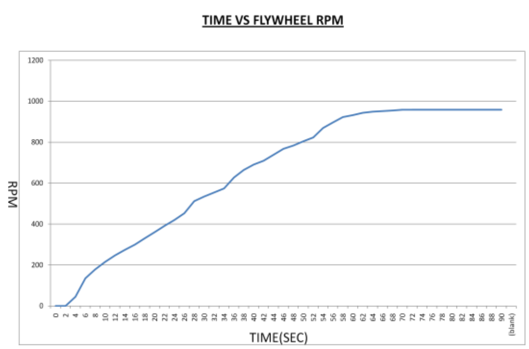

Fig. 20 GRAPH OF TIME Vs FLYWHEEL R.P.M.

From the figure no.19 and 20 , we have plotted a new graph in figure no. 21 which is cumulative of figure no. 19 and 20 shows that motor r.p.m. decreases while the flywheel r.p.m. increases with respect to time . it is due to the fact that motor supplies the energy to the flywheel to accelerate and its r.p.m. decreases , as the flywheel fully accelerates at maximum speed than it becomes almost constant after 68 seconds.

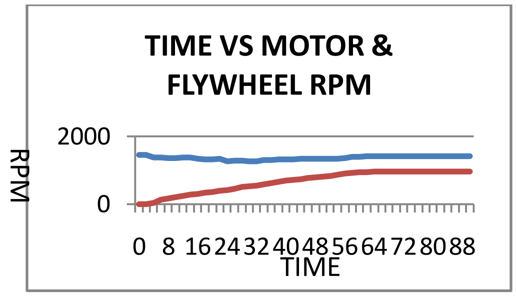

Fig. 20 GRAPH OF TIME Vs MOTOR & FLYWHEEL R.P.M.

7. DISCUSSION

From the table no. 3 , it is clear that in the prototype soft starting arrangement the motor used is 2000 times reduced while the flywheel used is of 175 times reduced and by using this type of soft starting arrangement we can reduce the horse power of the motor and also the starting of the motor becomes soft starts rather than hard starts.

A graphs (figure no.20)is plotted between time in seconds and the motor and flywheel rpm which shows the change in motor and flywheel rpm with respect to time. When we compare the fig no.12 and 20 , it is clear that the r.p.m. motor by using the soft starting drive is not so much reduced as compared to the motor r.p.m. used in the rolling mill, hence due to this motor is not on loading condition and may draw the maximum current.

The motor ratio is decreased is 2000 times while the flywheel ratio is decreased only by 175 times , in order to make the flywheel effective and quite enough to drive the mill .

Initially the motor rpm decreases (figure no. 12 and 20) and flywheel rpm increases as the motor supplies the energy to the flywheel and after some time when flywheel rpm becomes constant again the motor rpm increases which shows that the motor supplies the energy to the flywheel and after fully charged flywheel than recovers the energy.

In authors' view the probable area of the energy conservation is in the main electric motors and it has proved by the researchers [6] that the oversized motors are used in rolling mill as to drive the flywheel and the mill. Also [3] it has been calculated that the power requirement during the mill running is very less. Hence mechanical soft starting arrangement can be possible to run the main motor by using the flat belt drive soft starting arrangement.

8. CONCLUSION

It is suggested that, there is large scope of minimizing the energy consumption in main electric motor of rolling mill

1. The selection of the flexible drives available in mechanical, electromechanical, chemical, electronics system and designed a suitable soft starting arrangement for the rolling mills may become the future of the rolling mills of new decade and definitely we solve the energy crises.

2. To design a system which is capable of starting the system with low horse power motor and to design a some alternative arrangement which can serve this purpose.
3. It is the opinion of the authors that the simple design in using the flat belt drive mechanical soft starting arrangement, the energy consumed by the electric main motor can be reduced .

4. To design a some more alternative arrangement which can serve this purpose.

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