Dynamic Simulation of Three High Rolling Mill Run by Two Prime Movers

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Abstract

This paper presents the static and dynamic analysis of three high rolling mills run by two prime movers. The rolling mills normally reduce the billets of (100 mm x 100 mm) size to 12 mm round in 12 - 21 successive passes. The static and dynamic power requirement of the rolling varies from 100 Hp to 800 Hp depending on the product being rolled and the size of input billets. In this paper a computerized simulation model was given for analyzing the dynamic response of the mill, studying the loading pattern and its statistical distribution. The dynamic response was calculated in terms of flywheel energy requirement which in turn can be represented in terms of fluctuations in angular speed of flywheel. The drive system suggested can comprise of a combination of two prime movers which can supply the desired power to the system singly or in combination. This analysis is helpful for all the designers of the rolling mills for optimizing the power consumption in the rolling mills.

***Keywords**: Static, Dynamic, Prime Mover,*

1. Introduction

The entire world is facing energy crisis and situation in this regard is going from bad to worse due to rapidly depleting source of conventional energies. A large chunk of electrical energy is consumed by corporate sector for industrial production. Steel rolling industries are mainly dependent on the electrical energy and about 70% to 80% of electrical energy is spent on rolling operation and balance is consumed on ancillary operation like cutting of roll stock, furnace blower, crane operation etc. The ever 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 a major part in the cost of rolling.

Our country produces around 40 million tons of steel, out of which 50% is produced by small three high rolling mills. An average of 400 crore units of electricity is consumed in rolling steel bars and other product mix hence there is a great scope for considerable saving in electricity by proper selection and 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 selected for meeting the power demand for every operation hence the concept of novel idea of installing two prime movers is mooted for such a varying power demand. In this work a drive system for three high open train rolling mills is designed with two prime movers. The present work attempts to analytically estimate the static and dynamic behavior of the two prime movers under the action of varying load of open train rolling mill. It is estimated that the static and dynamic power requirement of rolling mill varies from 100 Hp to 800 Hp depending on the product being rolled and the size of input billets.

The main idea of this work is the proposal of running a rolling mill with a set of two prime movers. In this work it has been examined theoretically the possibility of deploying two prime movers of different sizes which may be used for rolling of different types of products. It is a general observation that two prime movers if connected to same load would require careful synchronization so that the load sharing by both the prime movers is proportionate and uniform. The present work explains the concept and design approach to mechanically synchronize the two prime movers with its static and dynamic analysis.

2. Dynamic Analysis Using Computer Simulation

The calculation of dynamic energy requirement of any rolled product in the rolling mill begins with static energy requirement calculations. The static energy in the rolling mill is the minimum energy required for rolling a particular product. The static energy requirement depends upon the pass sequence followed for that product and the draughting in every pass. Individual static energy requirement was calculated for every such pass using the standard procedures based on earlier investigations. Static energy calculations were done for every pass considering the rolling of that pass only. A Fortran software was developed to carry out all the calculations. The static energy requirement for 16 mm round are presented in Table1.The table indicates the energy required per pass for converting a billet of 90 mm X 90 mm to 16 mm round in seventeen passes. This static analysis forms the basis for dynamic analysis. The dynamic analysis was carried out using Monte-Carlo simulation approach. The Monte Carlo simulation simulates the entire loading cycles for the overall working of the machine for a finite duration. The inter arrival timings of loading were first calculated for each ingot. As their individual energy consumption was already known from the static analysis. The computer software was developed to evaluate the energy requirement of such process for each second over the entire span for which the simulation was done The software can also give second wise flywheel energy demand of the mill over the selected time span. The occurrence of peak energy demand from the results of dynamic analysis of the rolling operation and its intensity can be used for the optimum selection of the drive combination of induction motor and a flywheel for the rolling mill.

Table.1 Static power consumption for 16 mm round bar

Energy drawn per pass(Hp sec)	Power required per pass(Hp)	Time taken per pass(Sec)
105.3294	321.8671	0.327245
137.1566	357.0325	0.3841572
67.59201	151.6017	0.4458525
195.729	394.4305	0.4962319
243.9324	379.0268	0.6435755
222.9682	240.3893	0.9275297
364.8849	330.8793	1.102774
260.736	154.5012	1.687598
215.1163	92.96879	2.313855
212.508	98.63997	2.154381
302.8185	122.6924	2.468112
245.2994	75.18289	3.262702
269.7202	71.03329	3.797096
255.5057	51.76136	4.936225
225.3343	43.13842	5.223518
278.2262	45.06449	6.173955
87.94819	12.03307	7.308874

2.1Dynamic Simulation Results

The summary of the dynamic simulation result for 16mm round is shown in the table 2 with different motor rating.

Table.2 Flywheel energy demand for 16 mm round

Motor Hp	No. Of Seconds. In Hour When Flywheel Demand Exceeds Following Hp-Sec Value							
	150	200	250	300	350	400	500	600
200	217	151	97	60	42	31	17	9
250	98	60	35	20	16	10	8	2
300	37	20	11	8	4	4	1	0
200+100	37	20	11	8	4	4	1	0

The above table indicates the dynamic response of the mill calculated by the software developed for a span of 3600 seconds i.e one hour. Entry in row1 coloumn1 indicates that while rolling 16 mm round starting from 90mm x 90mm billet using 200 Hp motor, the flywheel energy demand exceeds the value of 150 Hp sec 217 times in a span of one hour. Similarly row1 column 8 shows the entry value 9 which indicates that flywheel energy demand exceed 600 Hp sec 9 times in an hour. Likewise if the same product is to be rolled by a 300 Hp motor it never exceeds 600 Hp sec in an hour. When the same product is rolled by a combination of two prime movers it is found that the energy demand is almost same. This shows that the dynamic simulation results for one prime mover and two prime movers are practically same as reflected on the flywheel. It is the load sharing which differs in case of two prime movers connected to the rolling mill and for all practical purpose the simulation process and the analysis process remains same.

3. Observation from the Process of Synchronization of Two Motor

It is observed that for making both the motors to work at full load, a mechanical arrangement where in the transmission ratio of the two electric motors connected to the flywheel is adjusted so as to take care of varying load sharing properties of the two motors to be synchronized. Table 3 & 4 gives the load sharing as a percentage of full load capacity v/s operating speed for both motors before & after suitable design modification respectively. Table 3 indicates that a 300 Hp motor gives maximum power at about 735 rpm while 150 Hp motor gives maximum power at 730 rpm. After design modification both the motor can give maximum power at same rpm i.e 735 as indicated in Table 4.It is clear from the Table 3 & 4 that the load shared by each motor as percentage of full load rating was quite different for the two motors that were to be synchronized but a small design modification of altering the transmission ratio approximately by one percent can easily synchronize the two motors and from the Table 4 it is quite evident that the two motors will share approximately the same load. Hence, by this method designer of the rolling mill can easily synchronies the two prime movers.

Table . 3. Load shared as a percentage of full load rating before design modification

Motor Rpm	750	747.5	745	742.5	740	737.5	735	732.5	730
300 Hp	0	22	45	68	90	100	100	99	98
150 Hp	0	12.5	25	37.5	50	62.5	75	87.5	100

Table. 4. Load shared as a percentage of full load rating after design modification

Motor Rpm	750	747.5	745	742.5	740	737.5	735	732.5	730
300 HP	0	22	45	68	90	100	100	99	98
150 HP	0	20	40	60	80	99.2	100	100	99

4. Different Ways of Multiple Prime Movers Deployment

The multiple prime movers deployment problem can be tackled in two different ways apart from the one suggested here. For making the arrangement in the rolling mill as shown in the figure 1 extra expenses have to be incurred, one more flywheel and pinion box on other side of the mill will mean extra capital expenditure.

For making the arrangement in the rolling mill as shown in the figure 2 synchronization problem can be eliminated by installing two prime movers on both side of the main drive pulley with two different independent coupling. In this process at a time one motor will give the power. The disadvantage is that it requires higher size of motor on both the side which again means more cost is to be spend on motors.

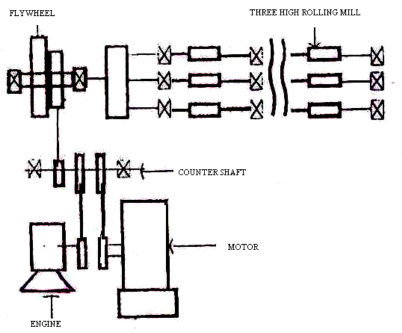

Fig.1.Design of rolling mill with two flywheel and two motor (concept one)

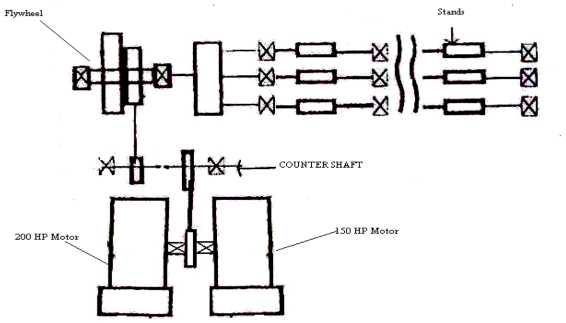

Fig.2.Design of rolling mill with motor on both sides of the main drive (concept two)

The work presented here i.e the third way means connecting the main flywheel shaft with two prime movers simultaneously with suitable arrangement for the synchronization of load sharing of two prime movers. This is the main idea discussed throughout this project although other ideas are also feasible solution of multiple prime movers.

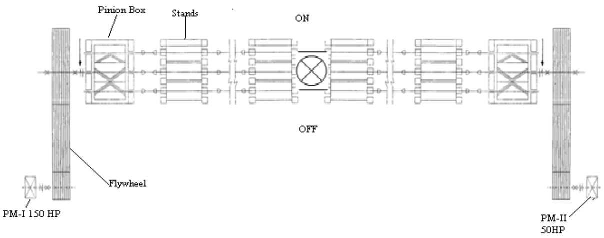

Fig 3.Design of rolling mill with multiple prime movers (Main idea)

It is well known principle of management that there are no free lunches in life. If we go for first method it means extra expenses required for flywheel and pinion box. The second method means higher sizes of motor are required which again means more cost. The third method means expenses on synchronization require to be done.

The simulation result are independent of the process by which we supply energy to the rolling mill either by process first as shown in figure 1, process second as shown in figure 2, or by process third as shown in figure 3,the simulation results are identical. But in our opinion the process suggested in figure third is although a little difficult from synchronization point of view but would prove to be economical and effective solution for running the rolling mill.

5.Discussion and Conclusion

It is clear from the dynamic analysis though the instantaneous energy demand is high, but such instances are very rare and hence employing a higher size motor only for such stray occurrences is not advisable.

In a rolling mill there is a belief that if the miller employs higher size of motor more will be its life. Failure of motors in rolling mill is not due to peak loads but because of poor maintenance etc. Dynamic analysis is particularly helpful in removing this false belief and also its accurate analysis helps in designing the correct size of motor for a particular product mix. The method suggested here of keeping multiple prime movers will not only help in selecting correct size of the motor but also it will save substantial amount of energy in the rolling mill.

From economic consideration, the running cost of correct size motor is 10-12% less than the oversize motor which is fitted in these mills. When an average monthly bills of rolling mills were examined it is approximately 4 to 8 Lakhs per month in an average, saving of 10 to 12% is straight saving of 40 thousand to 80 thousand Rs. per month. Hence it is felt that the suggested combination will be of great help to the rolling mill industry.

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7. Reference

[1] Winchester, A.J.(1964) “How to get and use rolling mill power data”, *Iron and steel journal*, july1964 pp 92-97.

[2] Tekadpande,S.M, Bapat, P.M. and Katkar,A.J. (1999) “Experimental verification of simulation results of three high open train mill” *Tenth world congress on theory of machines and mechanism, university of Oulu, Finland,* June 20-24,1999.

[3] Tekadpande,S.M, Bapat,P.M. and Katkar,A.J. (1995) “Analysis of static power requirements of existing rolling mill” *Proceedings of all India seminar on energy Management, Ecoenergy-*1995”pp 122-127.

[4] Agrawal,P.S. and Bapat,P.M. (2010) “A simulation approach for studying energy consumption in rolling mill and effect of power delivered by prime movers”, *International conference on operation and management sciences-2010*, Feb 2010, IMT, Nagpur. pp 14-15.

[5] Tekadpande,S.M, Bapat,P.M. and Katkar,A.J. (1997) “Energy conservation in open train rolling mill through dynamic analysis-A computer simulation approach”*, IPROM-97,*pp. 62-65.

[6] Puranik,P, Bedi,G. and Rochwani,S.(1997) “Static and dynamic analysis of commercial rolling mills”, Deptt of production Engg, M.I.E.T, Gondia, (India),1997.

[7] Pathak,A, Pillai,R. and Singh,A. “Effect of roll pass design on energy consumption of open train rolling mill”, Dept. of production Engg, M.I.E.T, Gondia.

[8] Polukhin,P, Fedosov,N. and Matveyev,Y. “Rolling mill practice”,Peace publishers,Moscow.

[9] Burtsev,K. “Rolling practice”, Mir publishers-Moscow.