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Design and Analysis of Hydraulic Roller press frame assembly

N.VENKATESH[1], G.THULASIMANI[2], JAYACHANDRAN.R[3], HARIRAMAN.R[4], S.V.ARUNBALAAJI[5]

[(1)] Asst.Professor, Department of Mechanical Engineering, Knowledge Institute of Technology, Salem, Tamilnadu
[(2, 3, 4, 5)] Student, Department of Mechanical Engineering, Knowledge Institute of Technology, Salem, Tamilnadu

(nvmech@kiot.ac.in[1], thulasimanimech@gmail.com[2], hcsjaichandran@gmail.com[3], hariramanr07@gmail.com[4], arunbalaaji95@gmail.com[5])

Abstract: The main aim of this present work is to re-design the existing frame assembly of Hydraulic roller press 3.00 which has been used widely for grinding the hard clinker materials in cement industries. By carrying out this optimization work, it is proposed to reduce the overall weight of the frame assembly and thereby reducing total cost of the machine to make the product competitive in today's market scenario. This frame assembly consists of mainly two upper frame members and two lower frame members made up of steel which are having maximum thickness of 260mm. These higher thickness plates are not available as standard thick plates for procurement.

Keywords: Hydraulic roller press, optimization, hard clinker.

INTRODUCTION

Cement as construction material:

In the most general sense of the word, cement is a binder, a substance that sets and hardens independently, and can bind other materials together. The word "cement" traces to the Romans, who used the term opus caementicium to-describe masonry resembling modern concrete that was made from crushed rock with burnt lime as binder.

The volcanic ash and pulverized brick additives that were added to the burnt lime to obtain a hydraulic binder were later referred to as cementum, cimentum and cement.

The most important use of cement is the production of mortar and concrete the bonding of natural or artificial aggregates to form a strong building material that is durable in the face of normal environmental effects.Concrete should not be confused with cement, because the term cement refers to the material used to bind the aggregate materials of concrete.

Concrete is a combination of a cement and aggregate. Clinker is ground (usually with the addition of a little gypsum, that is, calcium sulfate dihydrate) to become Portland cement.

Fig.1 Clinker shapes

SCOPE OF THE PRESENT WORK

At present the Hydraulic roller press (HRP) is used for clinker grinding purposes in all the cement manufacturing plants in our company. This machine is preferred mainly due to its less power consumption and its ability to grind very hard materials.

In the existing system of Hydraulic roller press 3.00, the frame assembly plays a major role in the function wise as well as in cost wise. The frame assembly consists of higher thickness solid cross section plates in its existing construction. Since the required higher thickness cross section plates are not easily available for procurement, now there is no other alternative than to essentially resort to import the same for incorporating in the existing machine. This importing of higher thickness plates increases the total cost of the machine and thereby it creates tough competition in selling this machine in this competitive world.

Hence in order to achieve the maximum cost reduction by avoiding importation it is planned to remove the single solid plate construction of higher thickness frame members and in its place use the standard available cross section / standard thickness plates available as standards by totally redesigning the whole frame assembly for achieving the maximum optimization and cost reduction.

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METHODOLOGY

I. Frame Data collection

- Find the type of cross section used.
- Find out yield strength of the material.
- Find out the existing boundary conditions for conducting analysis.

II. Analysis

- Perform analysis using Stress analysis and simulation software (ANSYS-11) on frame members with existing boundary conditions.
- Redesign the frame members of various cross sections with standard thick plates having proposed factor of safety.
- Review the results and find out the optimised cross section.

LITERATURE REVIEW

J. Kala, Z. Kala from Department of Structural Mechanics, Faculty of Civil Engineering, and Brno University of Technology studied about “Influence of Yield Strength Variability over Cross-Section to Steel Beam Load-Carrying Capacity”. Authors of article analyzed influence of variability of yield strength over cross-section of hot rolled steel member to its load-carrying capacity.

In calculation models, the yield strength is usually taken as constant. But yield strength of a steel hot-rolled beam is generally a random quantity. Not only the whole beam but also its parts have slightly different material characteristics.

According to the results of more accurate measurements, the statistical characteristics of the material taken from various cross-section points (e.g. from a web and a flange) are, however, more or less different. This variation is described by one dimensional random field.

The load-carrying capacity of the beam IPE300 under bending moment at its ends with the lateral buckling influence included is analyzed, non-dimensional slenderness according to EC3is $\bar{\lambda} = 0.6$. For this relatively low slender beam the influence of the yield strength on the load-carrying capacity is large.

ROLLER PRESS OVERVIEW

Overview

The roller press is a machine for crushing and grinding hard, brittle materials, preferably cement clinker. The material to be ground is fed between two rollers which rotate in opposite directions and are forced against each other by a hydraulic pressure system. After passing the rollers, the material leaves the machine as flakes which are easily to grind.

Roller press, new energy-saving grinding equipment developed in middle 1980s, can replace the ball mill competently or in partial. Roller press is characterized by low power consumption and lower noise for reforming old factories

Fig.2 Hydraulic Roller Press at site

Construction of Hydraulic Roller Press

The hydraulic roller press consists of a frame assembly in which two rotating rollers are mounted with roller bearings and bearing housings. One of the two rollers is stationary during press operation. The other roller is movable and forced towards stationary roller by 4 hydraulic cylinders mounted in the roller press frame.

Planetary gear boxes with high reduction ratios have been mounted over the individual rollers. The main motors have been placed in the separate foundations. The drive from the main motor to the gear boxes are being obtained by having a connection cardan shaft with universal coupling between motor shaft and the gear shaft.

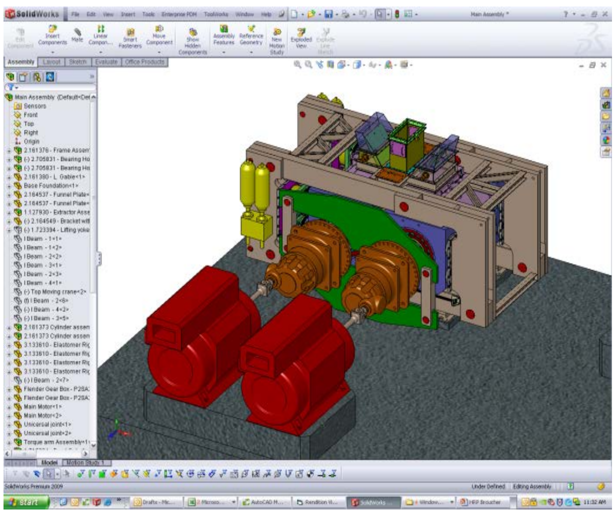

Fig.3 Hydraulic Roller Press with main drives

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ROLLER PRESS COMPONENTS

Frame assembly

The frame consists of two lower members, two upper members and three gable sections. The two identical gable sections support the cylinder arrangement. Each of the two gable sections is connected to the upper and lower members by means of plain bolts. Gable section is L-shaped (being referred to as L-gable) and differs from the two gable sections by means of closing one end of the frame. Like gable sections the L-gable is connected to the upper and lower members by means of plain bolts. Because the connection between L-gable and members consists of plain bolts, it is possible to turn the L-gable down and open the frame structure.

When the L-gable is turned down, the two roller sets complete with bearings and bearing housings can be pulled out into the opening and lifted out of the machine. As the L-gable is turned down, two supporting feet mounted on the L-gable are turned out. These feet are adjustable to secure that the L-gable is positioned horizontally which is necessary for moving the roller sets into and out of the machine.

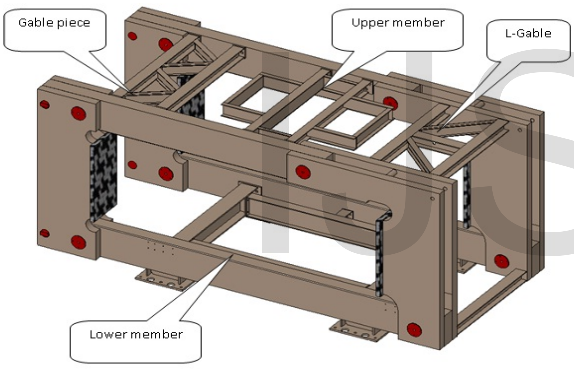

Fig.4 Frame Assembly

Bearing house assembly

The two grinding rollers of the roller press are both supported in spherical roller bearings which are built into separate bearing housings. The four bearing housings feature identical machining, but must be mounted on the rollers according to valid drawing. A finish-mounted bearing housing is supplied with sealing arrangements because of the dynamic oiling of the roller bearings. The bearing housings mounted on stationary roller are forced against four elastomer blocks mounted in L-gable of the roller press.

The purpose of the elastomer blocks is to absorb transverse effects originating from temperature variations or from skew running of the movable roller (which may be due to irregular feeding of material across the roller width or occurrence of foreign substances in the material fed). elastomer blocks are highly resistant to compression, but in comparison their resistance to shear movement is very small. This condition allows elastomer blocks to absorb any transverse loads between bearing housings and frame parts. Corresponding elastomer blocks are mounted between the bearing housings mounted on movable roller and hydraulic cylinders.

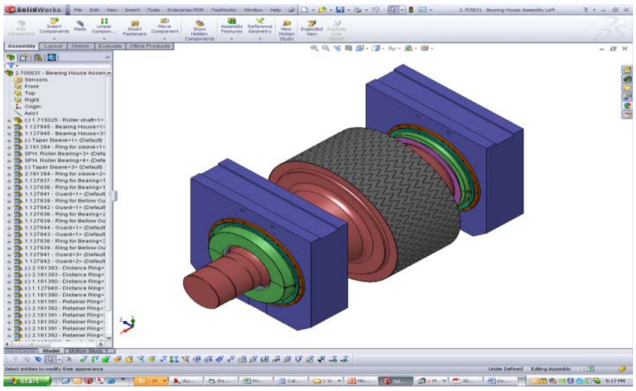

Fig.5 Bearing house assembly

SPECIFICATION OF ROLLER PRESS

The size of the Hydraulic roller press is normally specified by its project area of the roller. The projected area of the roller is defined as the product value of the roller diameter and the roller width. The size of the roller press ranges from 0.60 to 3.60. Here the specification details of the major parts such as Roller, Hydraulic system, Main drive and frame assembly for Hydraulic roller press 3.00 are given below.

Roller :

The roller is one of the major components that play a major role in the roller press during the grinding of clinker material. The roller is one of heaviest components in the roller press. The roller has been manufactured by means of forging process. The material used for roller is 30CrNiMo8. There are two rollers and each of them has been housed individually in each of the bearing housing. The roller gets the drive from main motor through gear box.

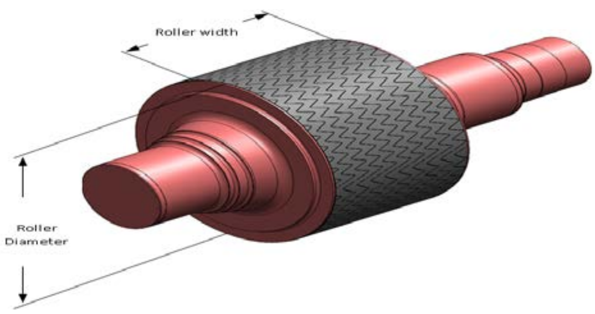

Fig.6 Roller

ROLLER DIAMETER (D1) : 2120 mm (2.12 m)
ROLLER WIDTH (W1) : 1410 mm (1.41 m)
PROJECTED AREA (Pj.ar : D1 x W1 = 3.00 m²

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Hydraulic System

The hydraulic system in the roller press is mainly used to produce the hydraulic force which is needed to press the hard clinker materials between rollers to form small clinker cakes. The hydraulic system consists of four hydraulic cylinders which are connected with accumulators. This hydraulic force is applied to the rotating rollers by pressing the movable bearing housing towards the stationary bearing housing. The details of the hydraulic system are shown below.

Specific grinding pressure (pr)	: 6000 kN/m²
Pressure applied	: By hydraulic power pack
No. of hydraulic cylinders used	: 4 Nos.
Piston diameter used (d1)	: 575 mm
Maximum grinding pressure (pr)	: 180 bar
Operating grinding pressure (pr)	: 140 bar
Nominal gap maintained between rollers during operation	: 50 mm

Table 1 Hydraulic system details

Main drive:

The system of main drive in the roller press consists of Main motor, Gear box and the coupling connection between motor and the gear box. The main motor used here is high rated kW motor. The coupling connection used between motor and gear box is Cardan shaft with universal joint which provides the smooth drive transmission between motor and roller during the movement of movable bearing housing. The gear box used here is planetary type with hollow output shaft and high reduction ratio. The gear box is mounted on one end of the roller shaft.

Roller output speed (Sp)	: 14.42 RPM
Main motor power (P)	: 2 x 1263 kW
Main motor speed (Sp)	: 990 RPM
Gear box type	: Planetary type – 2 Nos.
Gear box reduction ratio (Rt)	: 68.65
Coupling between motor and gear	: Cardan shaft with universal Joint

Table 2 Main drive details

SPECIFICATION OF MATERIAL
EN 10025-2 (2004)

Primary Standard:

EN 10025-2 (2004), MATERIAL: S 355 J2 FF, MATERIAL No.: 1.0570
Hot rolled products of non-alloyed structural steels - technical delivery conditions

CHEMICAL COMPOSITION (Table 2 in EN 10025-2 (2004)):

Dim. mm	% C max or range	% Si max or range	% Mn max or range	% P max or range	% S max or range	% N max or range	% Cu max or range
0-16	0.2	0.55	1.6	0.025	0.025	-	0.55
16-40	0.2	0.55	1.6	0.025	0.025	-	0.55
40-	0.22	0.55	1.6	0.025	0.025	-	0.55

MECHANICAL PROPERTIES AT ROOM TEMPERATURE:

Condi-tion	Dim. mm	Tensile Strength MPa	Yield Strength MPa	Elong. (l) %	Area Reduction		M.Elas GPa	Hardness			Imp. Energy KV, Min	
		Rm	Re	A5	Z	$Z_{\perp}$	E	HRc	HB	HV	°C	J
FF	2.5-3	510-680	355 -	18 -	-	-		-	-	-	-20	27
FF	3-16	470-630	355 -	22 -	-	-		-	-	-	-20	27
FF	16-40	470-630	345 -	22 -	-	-	210	-	-	-	-20	27
FF	40-63	470-630	335 -	21 -	-	-	210	-	-	-	-20	27
FF	63-80	470-630	325 -	20 -	-	-	210	-	-	-	-20	27
FF	80-100	470-630	315 -	20 -	-	-	210	-	-	-	-20	27
FF	100-150	450-600	295 -	18 -	-	-	210	-	-	-	-20	27
FF	150-200	450-600	285 -	17 -	-	-	210	-	-	-	-20	27
FF	200-250	450-600	275 -	17 -	-	-	210	-	-	-	-20	27
FF	250-400	450-600	265 -	17 -	-	-		-	-	-	-20	27

FRAME ASSEMBLY VIEWS

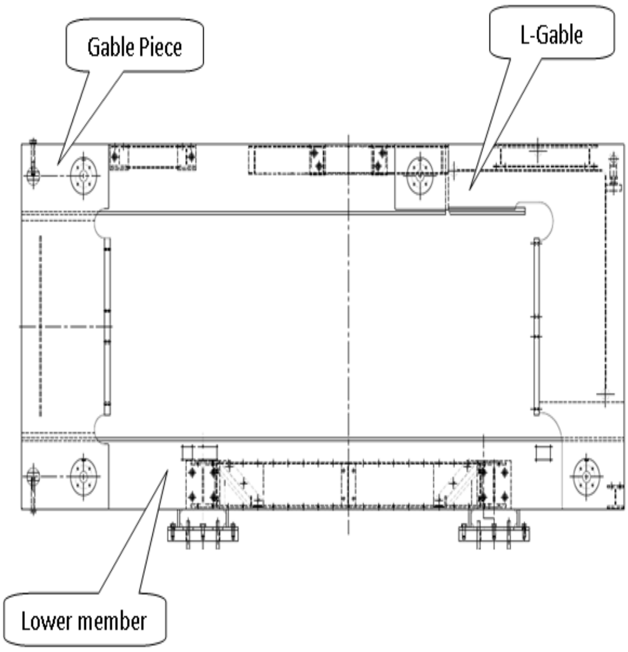

Fig.7 Elevation view of frame assembly

3D MODEL OF FRAME MEMBERS

Lower Right member and left member

The lower frame members form the bottom portion of the frame assembly. They are made up of higher thick plates. The 2 Nos. of bearing housing assembly rests on these lower members only. Hence the function of the lower members has to withstand the loads of the bearing housing.

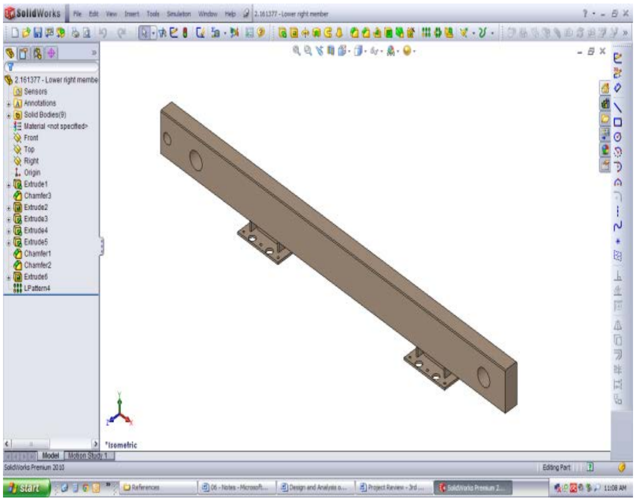

Fig.8 Lower right member and left member

Upper Right member and left member

The upper frame members form the upper part of the frame assembly. They are also made up of higher thick plates. It houses the inlet part and upper cross members of the frame assembly.

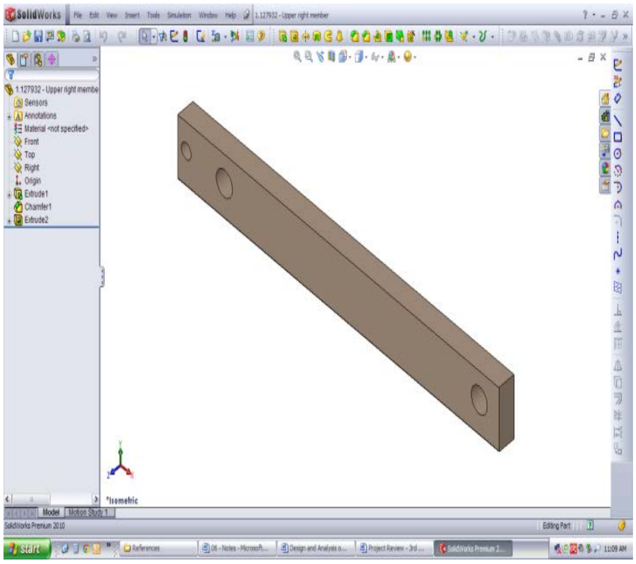

Fig.9 Upper right member and left member

ANALYSIS AND RESULTS

Boundary conditions on existing lower frame member

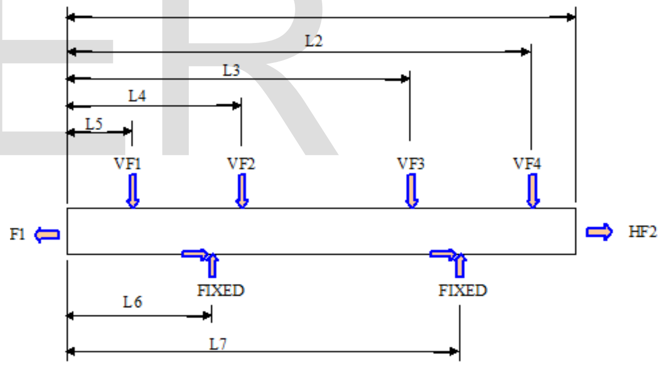

Fig.17 Boundary conditions on lower frame member

L1	=	7597 mm	HF1	= 9000 kN
L2	=	7122 mm	HF2	= 9000 kN
L3	=	5205 mm	L5	= 780 mm
L4	=	3035 mm	L6	= 2285 mm

L7= 5955 mm VF1 = 224 kN
VF2 = 530 KN VF3 = 530 kN
VF4= 224 kN

ANALYSIS AND RESULTS OF EXISTING LOWER FRAME MEMBER

Von-misses stress distribution plot

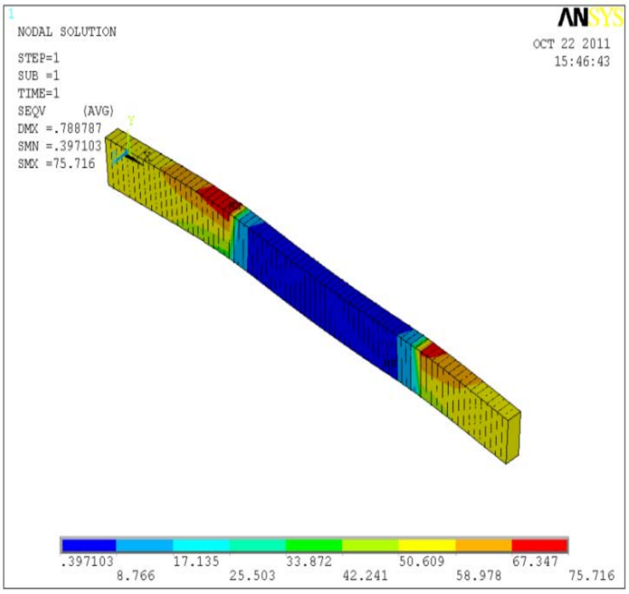

Fig.18 Von-misses stress distribution plot

Displacement plot

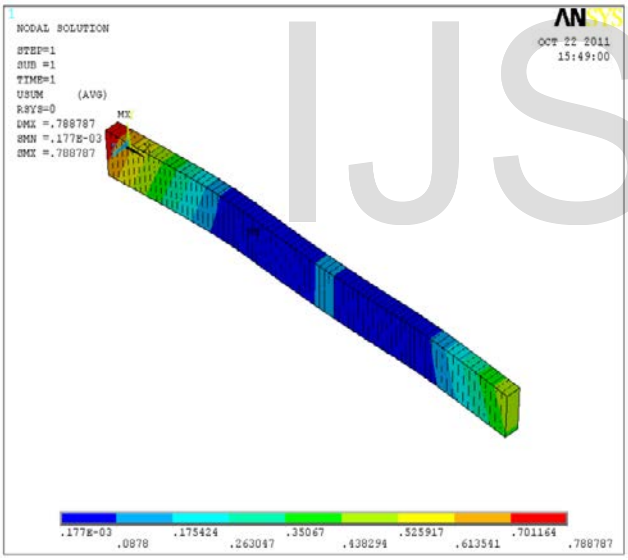

Fig.19 Displacement plot

RESULT AND ANALYSIS

From the above stress distribution the maximum stress value obtained is 76 MPa. But as we already know, the existing material yield strength is 265 MPa which we can refer from the material specification table. Therefore it is arrived that the factor of safety maintained in the existing frame assembly is 3.5.

Since the constraint on the factor of safety is to maintain 2.5 for this equipment, the maximum allowable stress value can be taken as 152 MPa for re-designing the frame assembly.

Hence with this as input, alternate cross sections have been modeled and the analysis has been carried out with the same above boundary conditions and analysis reports are depicted below.

CONCLUSION

Existing lower member of frame assembly has been modeled initially. Existing boundary conditions have been found for these frame members. Model has been analyzed with the existing boundary conditions.

As a result of this analysis, it is found that the factor of safety maintained in the existing design is 3.5 whereas the requirement is only 2.5. Taking this into consideration, alternate hollow cross sections with standard plate thickness have been modeled and analyzed using Stress Analysis and Simulation Software (ANSYS-11) with the same boundary conditions.

It is planned to design many other cross sections, perform the analysis and compare the analyzed results. Based on the reviewed results, optimised cross section will be selected and the lower frame members will be redesigned using the optimised cross section.

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