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Literature Review on Sugar Mill Coupling and It's Bearing Materials

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Abstract: In sugar mill power from driver to top roller is transmitted by solid shaft coupling. After that development is power transmission mechanism lead to improving is crushing efficiency. In this literature serve is done on the all most on coupling development studies. For the latest coupling called as rope coupling with spherical plain bush required selection of bushing material. Non-metallic bushing material studies and by Appling, AHP method material is sleeted.

Keywords: Sugar Mill, AHP, Link Coupling, Nylon Impregnated with 6% of oil, PEEK.

I. INTRODUCTION

In a sugar, mill power is transmitted from driver to top roller to do the cursing of sugar cane. Coupling between the driver and top roller used as tail bar coupling. In the process of cursing top roller will move vertically up to 40.23 mm depending on its design. So to compensate the driver for driven misalignment various coupling has been developing in stapes by stapes like the thrust bearing arrangement, wired coupling, new wired coupling, rope coupling with sling and rope coupling with spherical plain bearings to meet requirements of the crushing process.

Almost all needs of milling house are fulfilled by the last coupling called as rope coupling with spherical plain bearings. There is difficult to gate correct material for bushing/bearing. So we want to address on it. Non-metallic bushing material is studied with a property like compressive strength, specific wear rate, machinability, availability of material and cost.

II. LITERATURE SURVEY OF SUGAR MILL DRIVE

The tail bar coupling arrangement shown in fig.1. It consists of three parts. The tail bar is a combination of main 3 metallic parts not able to accept any radial or axial misalignment generated by sugar mill during crushing. To accept misalignment Female Square of coupling need to make bigger in size. It is simple to manufacture it used many years for crushing. The basic reasons for their continued use have been because they are very easy and are the cheapest combination. Intense metal surface wear patterns developed at the contact points of the center solid shaft, both end female shaft, drive square shaft and mill square shaft. [4].

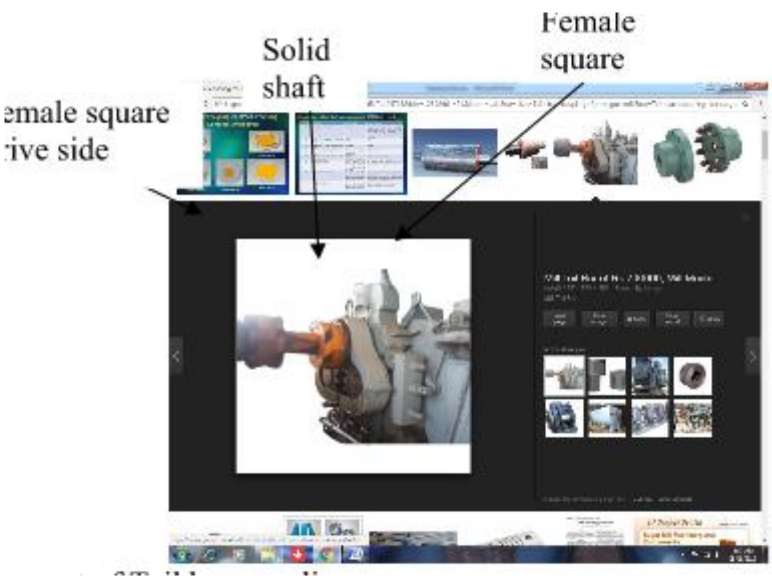

Fig. 1 Arrangement of Tail bar coupling.

This is typical arrangement shown to understand the overall layout of tail bar coupling.

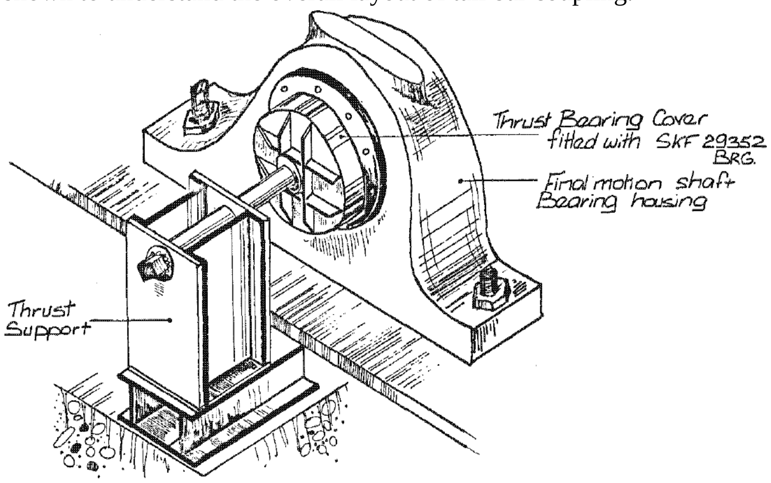

Fig. 2 Arrangement of the thrust bearing for mill final motion shaft [4].

This thrust bearing arrangement is able to increase milling process, but not able to overcome with axial and radial force generation. By putting this thrust bearing it will not stop the force generation in the process.

Rope coupling able to stop unwanted force generation. It should be noted that rope coupling is designed on the fact that sugar mill couplings are essentially unidirectional and require only modest misalignment ability of some 60 mm axial displacement and less than 1deg of angular misalignment.

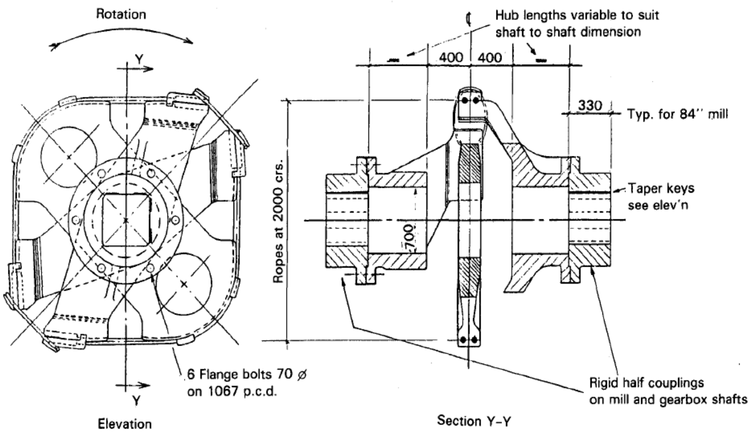

Fig.3 New sugar mill drive coupling [1].

New sugar mill drive coupling [1] will able to eliminate all axial thrust coming on top roller hence stop shaft break. It requires to rotation of the rope ones in three months. As it has 3-4 major components bigger in size and weight as compared to tail bar coupling so the cost of it will be two-time than tail bar couplings. As size is bigger it required more space for rotation. so need to take care of safety or required to installed safety guard around the coupling

It list noted the problems with tail bar coupling. Axial force generated around 147 kN for the 2134 mm mill with 2,440 mm long tail bar at 12.7 mm offset transmitting 930 kN-m torque, and considerably larger in most large mill drives because most tail bars are not as long as this and the conditions of the squares are invariably far from perfect. This axial force between mill and gearbox often results in damage to mill and gearbox bearings and has even been known to force shafts through final-drive gearing [2].Tail bar couplings also generate radial load 40% of the thrust loads. New Design coupling capable of it can be uncoupled in only 2 to 3 minutes, It is maintenance-free, It, can accommodate 100 mm of radial misalignment, 300 mm of end float and 3" of angular misalignment, all far more than required for a sugar mill coupling. The method of fixing to shafts has been changed from rigid keys to a simpler "slide-on-and-lock" system. The reversing ropes have been replaced by simple chain connection through lugs under the driving yoke-arm heads. The rope ferrules are new large in diameter and the rope-fitting is simplified. Disconnecting the coupling can be done within three minutes. The flange connection between the yoke and rigid-half coupling has been eliminated to ' reduce costs [2].

The material of construction of the main coupling components has been changed from cast steel grade A3 to fabricated steel Grade 300WA or cast steel grade A4 to reduce its cost. Because of fatigue problems caused by excessive misalignment, steel wire ropes have been replaced by two new types of flexible members: polyester slings and the link plates with spherical plain bearings. The coupling hub to be connected to the shaft square has been significantly redesigned to simplify installation and to ensure a more even distribution of pressure, even on damaged shafts. Week pin has been introduced to provide a mechanical torque limitation system to protect the coupling, shaft and gearbox components [3].

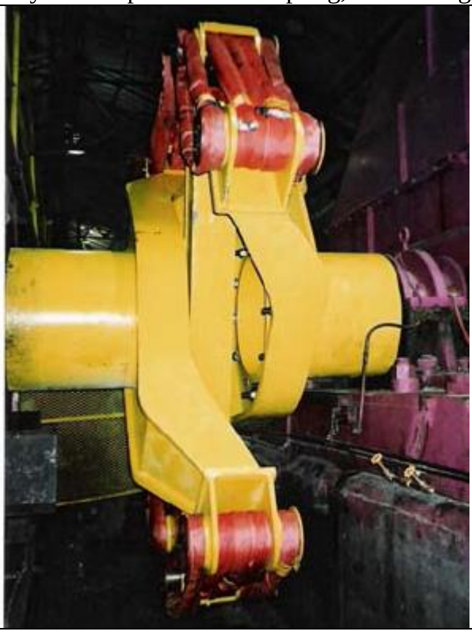

Fig. 4 Rope coupling with polyester slings. [3].

Fig. 5 Rope coupling with link plates fitted with spherical plain bearings. [3].

III.LITERATURE RESEARCH GAP IDENTIFICATION/PROBLEM DEFINING

Rope coupling with spherical plain bearings has the superior feature then all other couplings. Spherical plain bearings have not achieved the life predicted by the suppliers [3]. Rope coupling with spherical plain bearings has all features to full fill the crushing requirements. It consists of new hub design, forward and reverses member is same. We can reduce swing diameter if required.

Rope coupling with link plate fitted with spherical plain bush coupling solves all most all problem related to power transmitting and efficiency point of view. It doesn’t require another power transmitting member in reverse direction. So effectively reduce the cost of coupling as compare with rope coupling with a polyester sling. Rope coupling with link plate fitted with spherical plain bush has the following problem.

Objectives of the study as below:

1) Spherical bush life is not as per expectation.
2) Swing diameter is more than the tail bar coupling.
3) Cost is more than the tail bar coupling.

TABLE I

COUPLING PAPER WISE COMPARISON IN TABULAR

Sr. no.	Title of Paper	Publication details	Finding
1	Sugar-Mill Coupling Developments	Proc. Int. Soc. Sugar Cane Technol., Vol. 27, 2010	a) Material changes b) flexible member benefits and problems. C) Hub redesigns d) overload protection.
2	A New Sugar Mill Drive Coupling	Proceedings of The South African Sugar Technologists' Association - June 1988	Define the wire rope life, cost is the apex. twist than the conventional coupling
4	Sugar Mill Drive Couplings - An Alternate Design	Factory Engineering, Eurogear (Pty) Ltd, Johannesburg, South Africa	100 mm radial misl.,300 mm end float, 3◦ angulars; radial swing 1350 mm for 1600 Nm necessary because of steel rope.
5	Cane Mill Tail Bar And Coupling	FOR'I'Y-FOURTH CONFERENCE 1977	Any decrease in tail bar length will increase both forces, new flange coupling the constant movement of the mill top rollers, without the difficulties of extreme thrust loads

IV. LITERATURE SURVEY OF BUSH MATERIAL

The literature serves for the bushing material for our study done with available data. Out of that, we select the suitable material for experimental and simulation study. Following a group of material or their alloy is most used as the nonmetallic bearing without lubrication. For experimental study select the best material for our application on the basic of data available. We selected following listed material because of research paper available on this material and depending on physical availability or feasibility of material we take for experimental study.

Materials group according to the parent material. All listed materials having the most 1-8 property. We will study detail property of each group member.

1. SKF Filament wound.
2. Vesconite and Vesconite Hi lube
3. Nylon/Cast Nylon.
4. PEEK.

Listed materials in Table II are selected. One material from each group of material is selected.

TABLE II

LIST OF SELECTED 4 BEST MATERIALS FROM THE 4 GROUP OF MATERIALS COMPOSITE.

Sr. No	Material name	Publication detail/paper reference no
1	SKF bushings	SKF catalogue [6]
2	Vesconite Hi lube	Vesconite and Vesconite Hilube Design Manual [7]
3	Nylon impregnated with 6% of oil	The synthesis and frictional properties of lubricant-impregnated cast nylons [9]
4	PBI	Sliding wear properties of PEEK, PBI and PPP [8]

For selected four materials will undergo to analytic hierarchy process (AHP) to rank alternative materials in terms of their economic and performance.

A. **Problem Definition**: The problem is to select the best suitable material for link coupling considering that the cost is extremely important than the availability of the material. Mach inability is much more important than availability. Compressive strength is more important than machinability.

TABLE III
SAATY'S RATING SCALE

Intensity of Importance	Definition	Explanation
1	Equal importance	Both the factors are equally important.
3	Somewhat more important	One factor is somewhat more important over other.
5	Much more important	One factor is much more important over other.
7	Very much important	One factor is very much important over other.
9	Absolutely more important	One factor is absolutely more important over other.
2,4,6,8	Intermediate values	When compromise is needed.

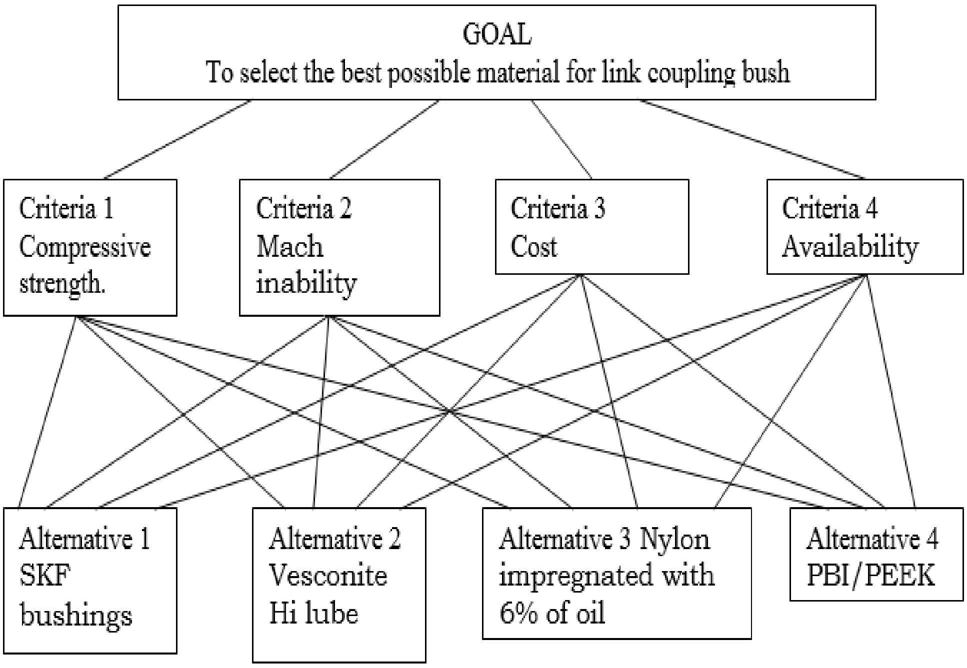

Fig. 5 Defining goal, criteria and alternatives.

B. Define Goal, Criteria, and Alternatives for material selection:

The second step in the material selection process is to make a decide the criteria's based on which material is access. Criteria's are the necessities of the material that should be satisfied. The criteria's for link coupling bush material are the compressive strength of the material, maintenance free (no lubrication required during operation), machinability, cost and local availability of the material. The alternatives available with us are too listed from four groups of materials. Our goal is to select the best suitable material satisfying our each criterion to the most excellent level. The alternatives available in a selection of material for link coupling bush are SKF bushing, Vesconite Hi lube, Nylon impregnated with 6% of oil and PBI/PEEK.

C. Pairwise comparison of criteria and finding Eigen value and priority value:

All the criteria are compared with each other for their significance to form generally preference matrix [5]. The saaty's scale suggests the weight of one criterion compare to other. Let us make the overall preference matrix. Eigen values are found out by using the geometric mean method. Priority value found: done multiplying the elements in

each row and taking their nth root, where n is a number of criteria.
In our case n= 4

TABLE IV
PAIR WISE COMPARISON OF CRITERIA

	Compressive strength	Mach inability	Cost	Availability	Eigen value	Priority value
COMPRESSIVE STRENGTH	1	1/2	5	3	1.65	0.33
MACH INABILITY	2	1	2	5	2.11	0.42
COST	1/5	1/2	1	9	0.97	0.19
AVAILABILITY	1/3	1/5	1/9	1	0.29	0.06
TOTAL	3.53	2.2	8.11	18	5.04	

Eigen value for the compressive Strength =(1*1/2*5*3)^(1/4)=1.65
Priority value for the compressive Strength=1.65/5.04=0.33

D. Evaluating alternatives for each criterion and finding out Eigen values and Priority value.

Nylon means nylon impregnated with 6% of oil for next reference.

compressive strength:

TABLE V
EVALUATING ALTERNATIVE FOR COMPRESSIVE STRENGTH.

	SKF bushings	Vesconite Hi lube	Nylon	PBI/PEEK	Eigen value	Priority value
SKF BUSHINGS	1	2	1/2	1	1	0.19
VESCONITE HI LUBE	1/2	1	1/9	1/5	0.32	0.06
NYLON	2	9	1	3	2.71	0.52
PBI/PEEK	1	5	1/3	1	1.14	0.22
TOTAL	4.50	17	1.94	5.20	5.17	

Machinability:

TABLE VI
EVALUATING ALTERNATIVE FOR MACHSINABILITY.

	SKF bushings	Vesconite Hi lube	Nylon	PBI/PEEK	Eigen value	Priority value
SKF BUSHINGS	1	1/8	1/9	1/9	0.20	0.04
VESCONITE HI LUBE	8	1	1	1	1.68	0.31
NYLON	9	1	1	1	1.73	0.32
PBI/PEEK	9	1	1	1	1.73	0.32
TOTAL	27	3.13	3.11	3.11	5.34	

Cost:

TABLE VII
EVALUATING ALTERNATIVE FOR COST.

	SKF bushings	Vesconite Hi lube	Nylon	PBI/PEEK	Eigen value	Priority value
SKF BUSHINGS	1	1/3	1/9	5	0.66	0.10
VESCONITE HI LUBE	3	1	1/8	1/2	0.66	0.10
NYLON	9	8	1	6	4.56	0.71
PBI/PEEK	1/5	2	1/6	1	0.51	0.08
TOTAL	13.20	11.33	1.40	12.50	6.38	

Availability:

TABLE VIII
EVALUATING ALTERNATIVE FOR AVAILABILITY.

	SKF BUSHINGS	VESCONITE HI LUBE	NYLON	PBI/PEEK	EIGEN VALUE	PRIORITY VALUE
SKF BUSHINGS	1	2	1/5	1/2	0.67	0.12
VESCONITE HI LUBE	1/2	1	1/8	1/5	0.33	0.06
NYLON	5	8	1	2	2.99	0.61
PBI/PEEK	2	5	1/2	1	1.50	0.27
TOTAL	8.5	16	1.83	3.70	5.49	

TABLE IX
E. FINDING TOTAL PRIORITY WEIGHT OF ALTERNATIVES WITH RESPECT TO CRITERIA.

	Compressive strength.	Mach inability	Cost	Availability	Priority value	Ranking
P.V. FROM TABLE IV	0.33	0.42	0.19	0.06		
SKF BUSHINGS	0.19	0.04	0.10	0.12	0.11	4
VESCONITE HI LUBE	0.06	0.31	0.10	0.06	0.18	3
NYLON	0.52	0.2	0.71	0.54	0.48	1
PBI/PEEK	0.22	0.32	0.08	0.27	0.24	2

Priority value calculated for SKF Bushing=0.33*0.19+0.42*0.04+0.19*0.10+0.06*0.12=0.11

CONCLUSIONS

The alternative having highest priority value shows that it is the good material according to the desired criteria's [5]. The maximum priority value of 0.0.48 for nylon impregnated with 6% of oil indicates that our first priority should be toward it. So we rank nylon impregnated with 6% of oil as the ranking number 1. The Priority value 0.24 of PBI/PEEK. is the second choice of the material ranking as number 2. Vesconite Hi lube and SKF bushings are 3, 4 ranking respectively.

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