Low Cost Automation by Material Handling System for Short Distance Material Transfer

R. S. Mundada[1] D. S. Bhalerao[2] O. D. Bhalerao[3] D. N. Korade[4]
[1,2,3]B.E Scholar [4]Assistant Professor
[1,2,3,4]Department of Mechanical Engineering
[1,2,3,4]Sinhgad Institute of Tech & Sci, Savitribai Phule Pune University, Pune, India

Abstract— The current financial crisis faced all over the world has posed tremendous challenges on the manufacturing organisations. Even at low volumes, and large variety, they have to be competitive with minimum investment. Low-cost automation can play an important role in this situation. Material handling and logistics are expensive operations which comprise of 10% to 80% of product cost and this tends to rise for inexpensive products. It is always advisable to minimize or if possible eliminate operator's involvement in transferring materials. This work is aimed at developing a simple, compact and robust material handling equipment that would suit almost any short distance material transfer task and create some degree of automation around the existing equipment and tools. Such a system would eliminate the need of power conveyors, chutes or roller conveyors that need operator attention and picking of jobs by hand to transfer it between two stations. The system would be of great use in manufacturing lines having u type or zigzag type layouts where human handling of jobs is presently unavoidable, as use of powered conveyors or gravity conveyors cause interruption in line operations. For design of parts detail design is done and dimensions thus obtained are compared to next highest dimension which are readily available in market. This simplifies the assembly as well as post production servicing work.

Key words: Low Cost Automation, Material Handling System, Conveyors

A. *Abbreviations:*

- MH- MATERIAL HANDLING
- LCA- LOW COST AUTOMATION
- CW- COUNTERWEIGHT

B. *Nomenclature:*

- m_1 = mass of empty pan, kg
- m_2 = mass of counterweight, kg
- θ = angle of inclination of conveyor,
- x = length of counterweight arm from axis, mm
- y = length of tray arm from axis, mm
- h1 = height of tray from datum, mm
- h2 = height of counterweight from datum, mm
- S_{yt} = yield strength, N/mm^2
- S_{ut} = ultimate tensile strength, N/mm^2
- Fs = factor of safety
- τ = permissible shear stress, N/mm^2
- g = 9.81 m/s^2
- k = combined shock and fatigue factor
- T = torque, N-mm
- n = speed, rpm
- L_{10} = bearing life, mill. rev
- L_{10h} =bearing life, hours
- C = dynamic bearing capacity, N
- P = bearing load, N
- d = wire diameter of spring, mm
- C_1 = spring index
- D = mean coil diameter, mm
- ξ = deflection of spring, mm
- K= Wahl factor
- τ_1 = permissible stress in spring, N/mm^2
- τ_2 =induced stress in spring, N/mm^2
- G=modulus of rigidity for steel wires, N/mm^2

II. INTRODUCTION

Material handling (MH) involves "short-distance movement that usually takes place within the confines of a building such as a plant or a warehouse and between a building and a transportation agency." It can be used to create "time and place utility" through the handling, storage, and control of material, as distinct from manufacturing (i.e., fabrication and assembly operations), which creates "form utility" by changing the shape, form, and makeup of material. It is often said that MH only adds to the cost of a product, it does not add to the value of a product. Although MH does not provide a product with form utility, the time and place utility provided by MH can add real value to a product, i.e., the value of a product can increase after MH has taken place [1].

A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyor systems allow quick and efficient transportation for a wide variety of materials, which make them very popular in the material handling and packaging industries [2]. Although a wide variety of materials can be conveyed, some of the most common include food items such as beans and nuts, bottles and cans, automotive components, scrap metal, pills and powders, wood and furniture and grain and animal feed [3].

Low Cost Automation (popularly known as LCA) is the introduction of simple pneumatic, hydraulic, mechanical and electrical devices into the existing production process or/and machinery, with a view to improving their productivity. These would also enable the operation of these equipment by even semi-skilled and unskilled labour, with a little training. This will involve the use of standardised parts and devices to mechanise or automate machines, processes and systems. LCA is a technology that creates some degree of automation around the existing equipment, tools, methods, people, etc., using mostly standard components available in the market with low investment so that the payback period is short [4].

S.Patil, A.Patil, P. Gunjawate, G.Rakate [4] observed that low cost automation results in increase in productivity, less human intervention, reduction in human fatigue and increase in profit. Patel C H, Mohan Kumar G C, Vishwas Puttige [6] concluded that low cost automation results in low space requirements, less human errors, no requirement of skilled operator and low investment.

III. OBJECTIVE OF THE PROJECT

The objective is to amalgamate the two concepts of LCA and MH for achieving effective material handling by developing material transfer equipment that:

1) Would minimize the operators handling of jobs for transferring them between stations (U type, circular type, or zigzag manufacturing lines)
2) Would be simple, robust and compact.
3) Would consume no electrical power.
4) Would require minimum maintenance.

IV. PRINCIPLE

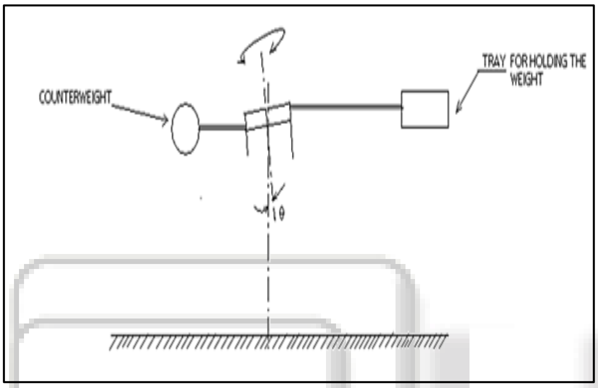

Fig. 1: Schematic Layout of the System

As shown in "Fig.1", the tray that carries the job is connected to a rotating assembly by means of an arm. A counterweight (CW) is attached diametrically opposite arm. Both the arms, i.e., the tray and counterweight arm are free to revolve about central axis. The entire revolving assembly is pivoted with its axis of revolution having a small inclination with the vertical.

The counterweight is selected such that it balances the weight of the empty tray at the topmost position (assuming negligible weight of arms). When the tray is empty, system has the tray arm at the top most position. When the part is kept on the kept on the tray the combined weight of the tray and part exceeds the counterweight and thus tries to attain a lower potential. This causes the tray to revolve by 180° about the axis of rotation, which results in transfer of jobs between two stations. Once the part reaches the destined station and is lifted from, the counterweight side becomes heavier than the tray side. So now the counterweight which had reached its maximum attainable potential tries to return backs to its lowest potential, causing the assembly to revolve again to acquire the initial positions. Hence the revolving tray moves from first station to second when a job is placed on it and returns back automatically to previous station once the job is removed from the tray. The system may work for any angle between 0° to 180°.

V. METHODOLOGY

A. General Considerations:

In system design we mainly concentrate on the following parameter:

1) System Selection Based On Physical Constraints:

While selecting any m/c it must be checked whether it is going to be used in large scale or small scale industry. In our case it is to be used in small scale industry. So space is a major constrain .The system is to be very compact. The mechanical design has direct norms with the system design hence the foremost job is to control the physical parameters.

2) Arrangement of Various Components:

Keeping into view the space restriction the components should be laid such that their easy removal or servicing is possible moreover every component should be easily seen & none should be hidden every possible space is utilized in component arrangement.

3) Components of System:

As already stated system should be compact enough so that it can be accommodated at a corner of a room. All the moving parts should be well closed & compact A compact system gives a better look & structure.

4) Chances of failure:

The losses incurred by owner in case of failure of a component are important criteria of design. Factor of safety while doing the mechanical design is kept high so that there are less chances of failure. Periodic maintenance is required to keep the m/c trouble free.

5) Servicing facility:

The layout of components should be such that easy servicing is possible especially those components which required frequent servicing can be easily dismantled.

6) Height of Machine from Ground:

Fore ease and comfort of operator the height of machine should be properly decided so that he may not get tired during operation .The m/c should be slightly higher than that the level also enough clearance be provided from ground for cleaning purpose.

7) Weight of Machine:

The total weight of machine depends upon the selection of material components as well as dimension of components. A higher weighted machine is difficult for transportation & in case of major break down it becomes difficult to repair

B. Input:

- m_1= mass of empty pan =3kg
- m_2= mass of counterweight =10kg
- θ= angle of inclination of conveyor =5^0
- x= length of counterweight arm from axis =300mm
- y= length of tray arm from axis =900mm
- h1= height of tray from datum =1000mm
- h2= height of counterweight from datum =980mm

C. Shaft:

Designation	**Ultimate Tensile Strength N/mm^2**	**Yield Strength N/mm^2**
EN24	850	680

Table 1: Shaft Material Property [11]

τ= 0.30 S_{yt}/Fs, (1.1)
= 0.30 x 680/2, (1.2)
=102 N/mm^2 (1.3)
τ = 0.18 x S_{ut}/Fs, (1.4)
= 0.18 x 850/2, (1.5)
= 76.5 N/mm^2 (1.6)
Considering minimum of the above values;
τ = 76.5 N/mm^2 (1.7)

Considering 100% overload or
k= combined shock and fatigue factor
= 2

$T= k\, m_1\, g\, y,$ (1.8)
$= 2 \times 29.43 \times 900,$ (1.9)
$= 52974$ N-mm (1.10)

Considering pure torsional load;

$\tau = 16T/\Pi d^3,$ (1.11)
$\tau = 16 \times 52974/\Pi (20)^3,$ (1.12)
$\tau = 33.72$ N/mm^2 (1.13)

Value of τ in "(1.13)" is less than that of "(1.7)". Hence, design is safe.

D. Bearing:

Bearing is selected according to application considering various factors such as load and lubrication.

For intermittent operation, $L_{10h} = 8000$ hours.

$L_{10}= 60nL_{10h}/10^6,$ (2.1)
$= 60 \times 100 \times 8000/10^6,$ (2.2)
$= 48$ mil rev. (2.3)
$C= P\,(L_{10})^{1/3},$ (2.4)
$=35 \times 9.81 \times (48)^{1/3},$ (2.5)
$=1247.81$ N (2.6)

Bearing of basic design No.(SKF)	d mm	D_1 mm	D mm	B mm	Basic Capacity (N)	
					Static C_0	Dynamic C
6004	20	23	42	12	4500	7350

Table 2: Deep Groove Ball Bearing [11]

E. Spring:

Spring is provided at the stopper end to stop the revolving tray at the second station, the object of the spring is to absorb the shock owing to the arrest of the revolving tray.

d = 2mm
$C_1 = 9$
D = Cd= 18mm
ξ = 10mm

$K=[(4C-1)/(4C-4)] + [0.615/C],$ (3.1)
$=1.16$

Diameter of wire mm	Steel wire unalloyed cold drawn			Spring steel oil hardened and tempered	
	Gr 1	Gr 2	Gr 3	SW	VW
2.0	1450	1750	2030	1720	160 0

Table 3: Average Values of Tensile Strength N/Mm2 [11]

$\tau_1 = 0.5\, S_{ut},$ (3.2)
$=0.5 \times 1450,$ (3.3)
$=725$ N/mm^2 (3.4)
$\tau_2 =K\,(8PC/\pi d^2),$ (3.5)
$= 195.60$ N/mm^2 (3.6)

Value in "(3.6)" is less than that of "(3.4)".
Hence, design selection is safe.

G=81370 N/mm^2

$N= \xi G d^4/8PD^3$ (3.7)
$= 9.48$ (3.8)
$= 10$ (approx.) (3.9)

VI. Material Transfer System

Part Code	Component	Part Code	Component
1	Tray	14	Tray Pipe Holder
2	Tray Pipe	15	CW Shaft
3	Bearing Housing	16	Weight Collar
4,5,6,7	Casting Plate	17	Hinge pin
8	Main Shaft	18	Spring
9	Fork	19	Spring holder
10	Fork Holder	20	Holder Slide
11	Boom Pipe	21	Damper Bracket
12	Base Flange	22	Stopper
13	CW Shaft Holder	23	Counterweight

Table 4: Components of the System

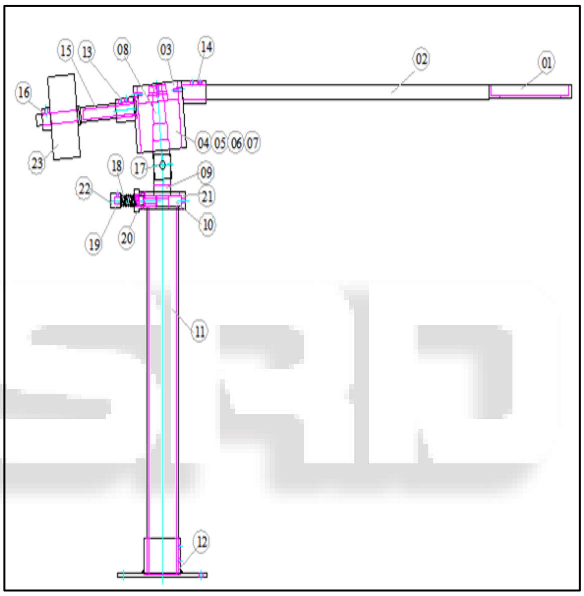

Fig. 2: Assembly of the System using AUTOCAD

VII. Conclusion

We have designed a material transfer system using the counterweight principle which will be helpful to small scale industries. Though it is suitable for light weight components and short distance transfer, it can be further improved accordingly by changing various parameters.

VIII. Acknowledgment

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