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DESIGN OPTIMIZATION OF DRAG CONVEYOR CHAIN : AN ANALYSIS FOR ENVIRONMENTAL IMPACT EVALUTION

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ABSTRACT
Abstract- Nowadays, environmental problems have aroused public awareness about the trade-off between economic growth and environmental conservation. In this regard, sustainable product development plays an important role for balancing the demands of social productivity and the conservation of natural resources. In the realm of sustainable development, life cycle assessment (LCA) is an important tool to assist in ensuring proper sustainability through assessing the environmental impacts of product designs. In this research we are emphasis on how we can optimize our product design by evaluating environmental impact.

KEYWORDS: environmental conservation, utilization, compressive strength, low cost, sustainable

INTRODUCTION
Over the last few decades, environmental issues (e.g. global warming, pollution and resource depletion etc.) have attracted much attention of product developers. Natural resources of the earth are so finite that human beings are being urged to take proper action to ease the situation. In response, life cycle assessment (LCA) is a tool that was developed to measure such environmental impacts. By using this tool we can analyze the environmental impact of our product and by initiating for sustainable development we can try to reduce the environmental impact.

Recently, focus has changed towards the environmental performance of the products and consequently product development has become of great importance, because a product's environmental performance is mainly determined during the product development process. Eco-design concept in product development is depends upon some key factors and they are: management, customer relationships, supplier relationships, development process, competence and motivation. [1]

By taking a systematic approach to the environmental design task, environmental product improvements can often be equated to increased product quality. At present, there are numerous examples of sustainable technologies, products and system solutions, which are sprouting up out of industrially driven initiatives, research centres and universities. A major motivation for these initiatives is the recognition that the goals of environmental and sustainable development can also be considered to be conducive to innovation and business creation. [2]

Despite today's green marketing campaigns, no engineering product is truly environmentally designed. It is necessary to know the environmental impact of a product, so that it can be developed further for the environmental design. The environmental impact of products and processes has become a key issue now. Industries have started to assess the impact of their activities on the environment. Therefore the need to assess the environmental impact of various products has been felt. [3]

CASE STUDY
In the environmental impact evolution for design optimization of drag conveyor chain we are performing a case study on 102mm. pitch drag conveyor chain and taking its specifications according to According to Indian Standards Specifications for Conveyor Chain IS : 6834 (Part I) – 1973 (Reaffirmed 2010) for chain of 102mm pitch recommend thickness of inner link is 6mm.

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DESIGN OF DRAG CONVEYOR CHAIN

A typical roller chain consists of alternate outer links and inner links. The outer links, which are sometimes known as "pin links," consist of spaced link plates each having a pair of openings or apertures. Pins are tightly fitted in the oblong openings of the outer links. The inner links, which are sometimes known as "bushing links," consist of spaced link plates each having a pair of oblong openings or apertures. Bush is tightly fitted in the apertures. The bush freely rotates about the pins, so that the inner links are pivotally connected to the outer links or able to articulate with respect to the outer links. Pin of drag conveyor chain are assembled in chain with the help of temporary fastening arrangement.

When this endless chain are moves in between drive and non drive ends of drag conveyor than through flight or projection a bed of bulk material are drags from feeding end to discharge end. This dragging action of material is applies forces on the flights of chain later on this forces are transmitted to the outer chain link and cause deformation of outer chain link. The deformation of outer link is apply forces on fasteners and tries to remove the fastener and break the temporary joint. Direction of forces applied on chain is shown in the figure 1.

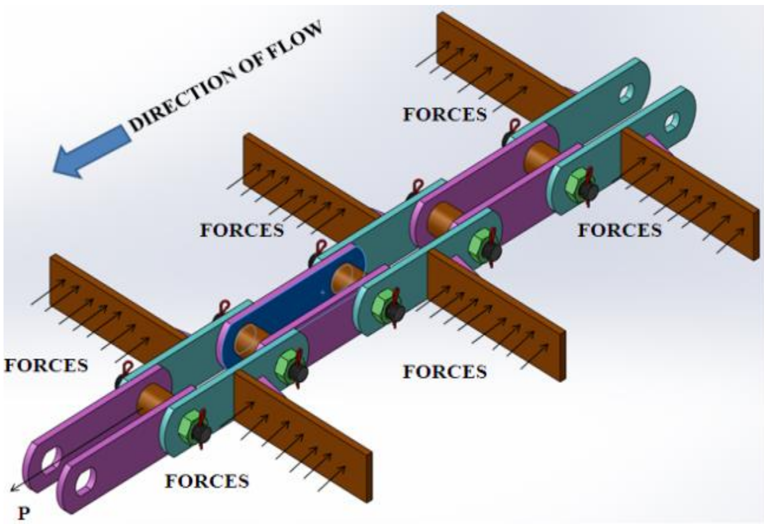

Figure 1: Drag Conveyor Chain

EXISTING DESIGN OF DRAG CONVEYOR CHAIN

In the existing design of drag conveyors chain nut is used as a fastener and they are fitted on the two threaded ends of pin. For preventing removal of nut due to rotation, vibration and sudden shocks a split dowel pin is pivoted in the holes at the ends of pin. This type of chain is failed due to following reasons.

Forces applied due to the dragging of material

Another reason of chain failure is miss alignment. If a chain is not properly aligned than at the time of contact of sprocket and chain that time sprocket is applies impact on the two inner link plates later on this impact will transfer in form of force to the outer link plate and cause removal of nuts.

In the figure 2 assembly and disassembly of existing design of chain is shown. This type of chain assembly mainly consist six parts and they are inner link, outer link, bush, pin, nut and split dowel pin.

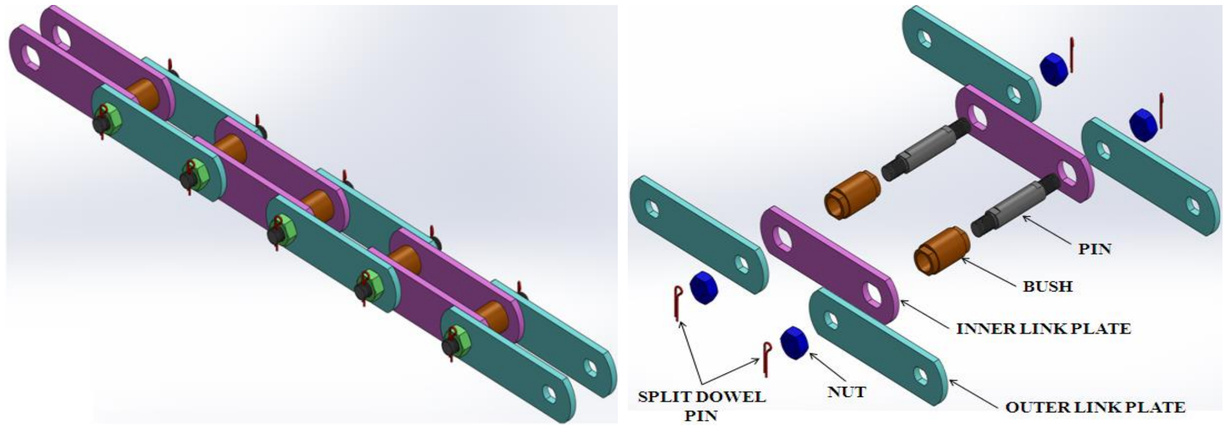

Figure 2: Assembly and Disassembly of Drag Conveyor Chain Existing Design

PROPOSED DESIGN OF DRAG CONVEYOR CHAIN

In the proposed design of drag conveyors chain we are trying to simplify the design of chain at hear we are replace the tedious and costly external threading operation at the pin ends with the simple turning operation through it we can save the material and tries to reduce the weight of chain.

Second change in the proposed design is we are replace the nut and split dowel pin with a single circlip and tries to make the more strength to the joint against the deformation and stresses.

In the figure 3 the assembly and disassembly of proposed chain design is shown. This type of chain assembly mainly consist five parts and they are inner link, outer link, bush, pin and circlip.

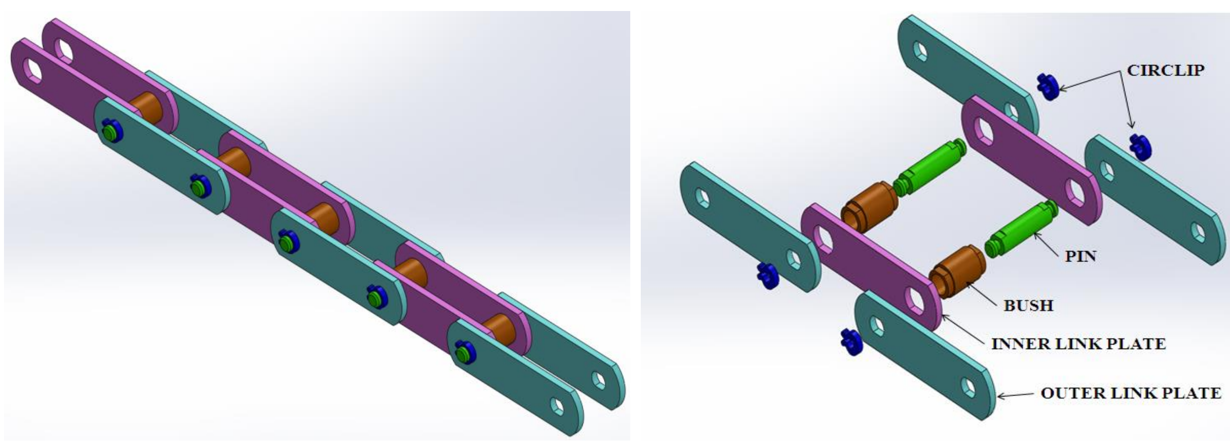

Figure 3. Proposed design of drag conveyor chain

COMPARISONS BETWEEN EXISTING DESIGN AND PROPOSED DESIGN OF DRAG CONVEYOR CHAIN.

We are comparing the existing design of chain with the proposed design at various phenomenons like Weight of Chain, Environmental Impact Assessment and FEA analysis of chain the following are the results of comparision.

Weight of Chain

Table 1. Comparison between weights of chain

PART	EXISTING DESIGN	PROPOSED DESIGN
	Weight in grams	
Outer Link Plate	259.4	259.4
Inner Link Plate	242.9	242.9
Bush	83.3	83.3
Pin	111.4	94.0
Circlip	Not used in this design	7.97
Nut	21.03	Not used in this design
Split dowel pin	0.9	Not used in this design
Per Meter Weight of Chain	7921.4	7574.4

Load

Wearing Capacity of Fasteners

CAD models of the chain are prepared in the Solidworks and then FEA analyses is being performed in Hypermesh using Optistruct solver. The results of analysis are viewed in the Hyperview.

Table 2. Input Parameters for FEA Analysis

INPUT PARAMETERS	
Young's Modulus	2.05e + 005 N/mm^2
Poisson's Ratio	0.3
Material Density	7.9 e -09 t/mm^3
Force Applied	+ ve X Direction

We have applied force of 5kN in +ve X direction on pin and fastener assembly and get the result of element stress which are shown in figure 4. At same force displacement is shown in figure 5

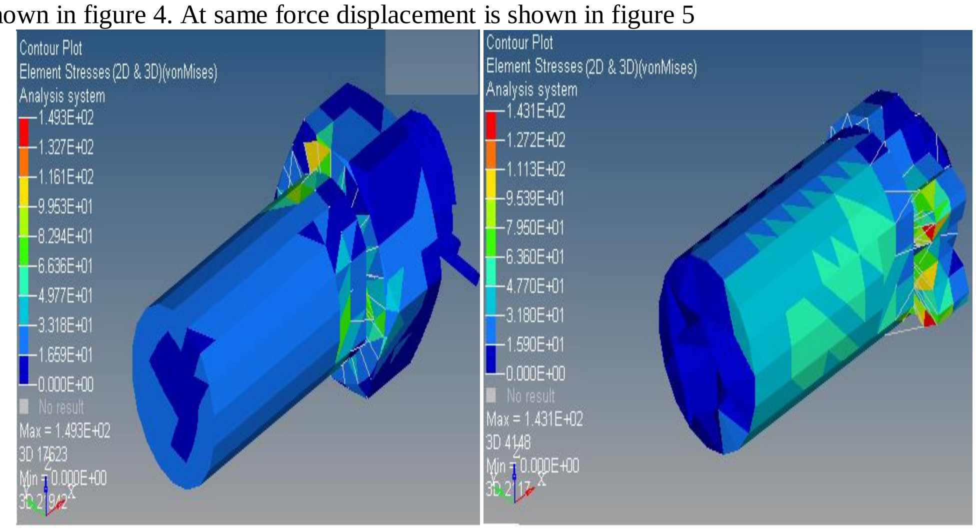

Figure 4. Element stress in pin and fastener assembly

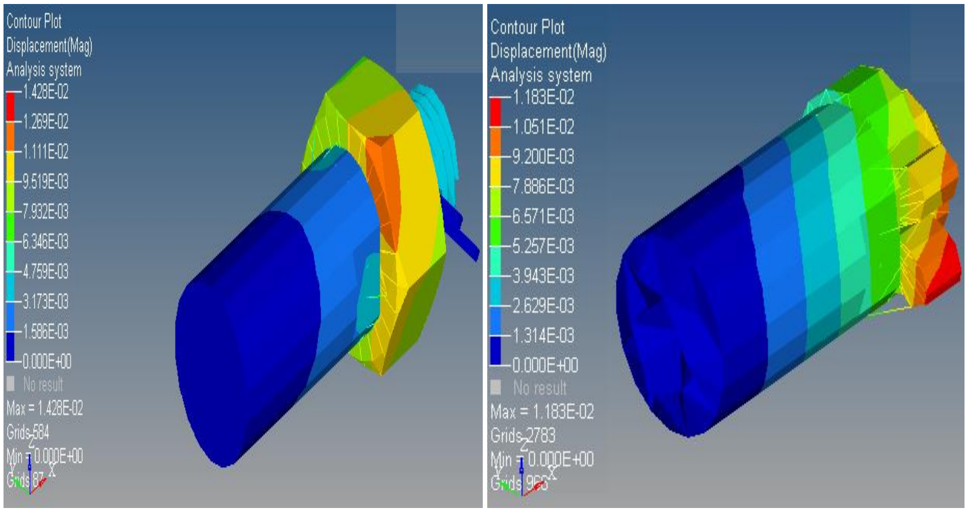

Figure 5. Displacement in pin and fastener assembly

Similarly we have applied forces of 10kN, 15kN and 20kn and get the result which is tabulated in table 3.

Table 3. Comparison between stress and displacementat different forces

Forces Applied (in kN)	EXISTING DESIGN		PROPOSED DESIGN	
	Stress In MPa	Displacement In mm.	Stress In MPa	Displacement In mm.
5	149.3	0.0142	143.1	0.0118
10	298.6	0.0285	286.2	0.0236
15	447.9	0.0428	429.3	0.0354
20	597.2	0.0571	572.4	0.0473

Figure 6 is showing a graph made by values using the values in table 3.

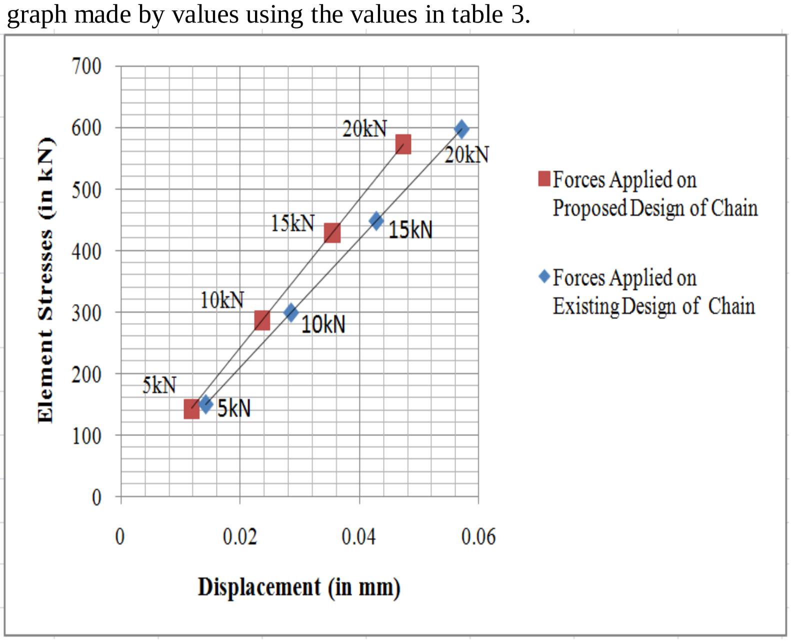

Figure 6. Graph between stress and displacement for existing design of chain and proposed design of chain at different forces

Environmental Impact Assessment [4]

The environmental impact assessment for the selected products covers two types of damages, eco-system quality and human health. The corresponding impact categories ecotoxicity water acute (EWA), ecotoxicity water chronic (EWC), ecotoxicity soil chronic (ESC), human toxicity air (HTA), human toxicity water (HTW), human toxicity soil (HTS), global warming (GW), acidification (AC), eutrophication (TET), ozone depletion (OD), have been considered for this work.

Here in this work, the environmental impact assessment of the parts of Drag Conveyor Chain (DCC) has been also evaluated at the material stage only, just for touching this aspect for making the sustainable product. It has done by using the LCA software "SSLCASoft" developed by Prof. Suman Sharma[9].

The impact indicator as result of the environmental impact of the product DCC at material stage is as shown in the figure figure 7

The impact of Human Toxicity Air (HTA) is dominating as compare to other impact categories. The second dominating impact categories in Ecotoxicity air (EWA). Then next impact are EWC and EWS.

In environmental assessment of proposed design of drag conveyor chain as compare to existing design we find out 4% improvement in environmental impact considering length of chain 100m.

Other impact categories have very less impact as compare to these. So they are not clearly visible in the graph (figure 7).

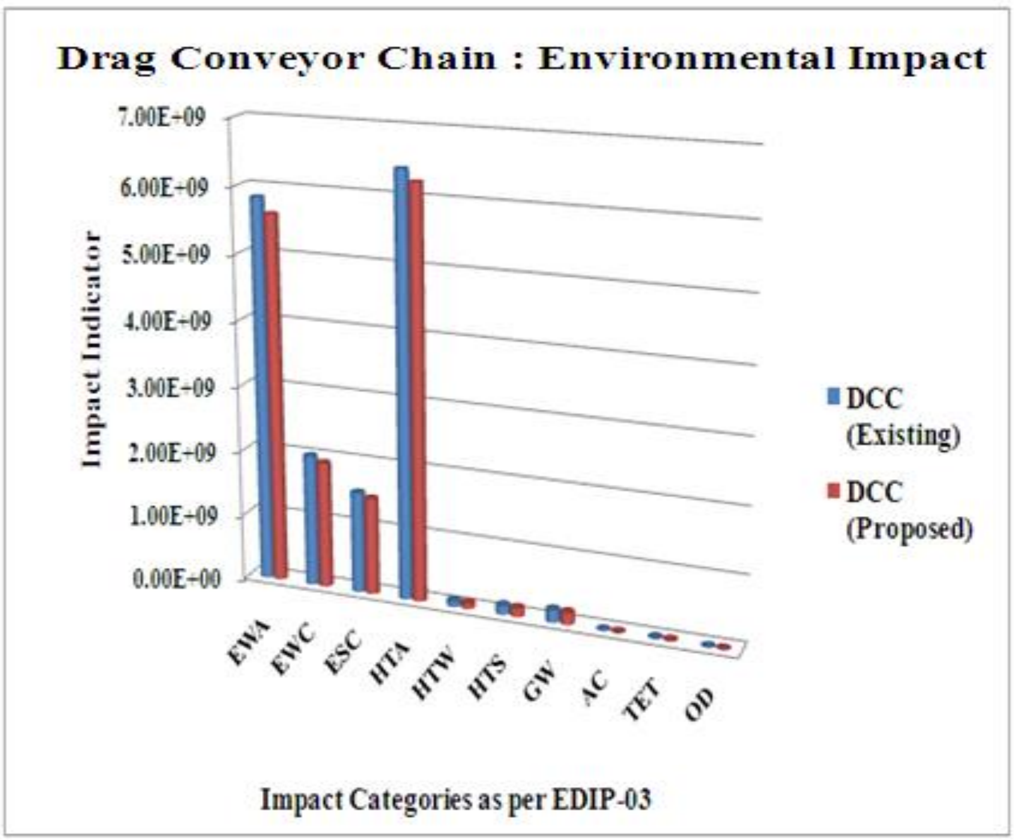

Figure 7. Graph For environmental impact assessment

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RESULTS

If we are comparing existing design with proposed design of chain then we found following benefits.

- Material saving up to 4.12% in per meter length of chain for same tensile strength by changing design of pin.
- Replace tedious external threading operation at the end of pins with simple turning operation and saves cost of operation and time.
- Eliminating drilling operation for split dowel pin.
- Replacing two fasteners split dowel pin and nut with a single fastener circlip.
- Reducing average element stresses by 4.15 by applying forces from 5kN to 20kN.
- Reducing average displacement by 17.1% by applying forces from 5kN to 20kN.
- 4% Improvement in Environmental Impact.

CONCLUSION

The proposed design of chain is performed better when forces are applied. By the proposed design of chain we can achieve goal of productivity by saving material and operations. The proposed design also help us in the standardization by replacing two fasteners nut and split dowel pin by single circlip. The proposed design is also found better for environmental imprudent. So we can say we can enhance performance of chain by implementation suggested in the proposed design.

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