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Design Improvement for Enhancing the Performance of drag Conveyor Chain and its Cost Reduction

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Abstract— Drag conveyors are the most efficient medium of material handling for conveying higher volume from one place to another. In horizontal condition drag chain conveyors can handle material up to 45-50% of cross sectional area of the trough. In between the drive and non drive ends of drag conveyor an endless chain, having wide links carrying projection or wings are drags a bed of bulk material from feeding end to discharge end. Drag conveyor chains are work under the very extreme conditions such as high tensile load, friction and some time hazardous operating environment (e.g. presence of humidity, chemicals). Due to versatile application various failures are occurred in the drag conveyor chain and causes loss of productivity and corrective maintenance in the system. In this paper we emphasis on appropriate design changes by which can reduce cost of drag conveyor chain and enhance the performance.

Keywords— Drag conveyors, material handling, trough, productivity, appropriate design changes, corrective maintenance.

INTRODUCTION

A chain is a reliable machine component, which transmit power by means of tensile forces and is used primarily for power transmission and material handling systems. In the drag conveyors for conveying bed of material from one place to another place a large pitch chain are used. Large pitch conveyor chains are critical component of conveyors in paper mill, sugar mill, fertilizer industry, pharmaceutical industry, cement industry, coal mine, heat treatment plant and food processing industry. In the drag conveyors a roller chain is wound around at least two sprockets, with the sprocket teeth engaging rollers or bushings between the links of the chain. Rotation of a driving sprocket causes power transmission through the chain and consequent rotation of at least one driven sprocket. This process is applied various forces on the chain and cause failure of components of chain assembly. In this research we are emphasis on failure of drag conveyor chain and trying to modify the design of pin and fasteners for enhancing performance and to meet the cost reduction by reducing the material and operations.

Today it is widely acknowledged that companies need to reduce the environmental impact of their activities. In the early days of industrial environmental consciousness focus was set on so-called “end of- pipe” solutions, i.e. solutions aimed at reducing the amount of harmful emissions and substances from manufacturing facilities. 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]

Most of the time chain is under tension which causes failure of chain assembly which is the major problem for industrial sector. Causes of this failure are improper design. It is important to study the influence of these parameters. All these parameters can be considered simultaneously and chain link design optimally. Optimization is the process of obtaining the best result under given circumstances in design of system.[2]

Failure of chain link and stress analysis is widely done by Finite Element Method (FEA & FEM) and design optimization tool. The chain links are considered different loading condition, different behavior of failure and design parameter. FEA apply in mechanical element and link, we find in which the parameter are effect to its failure.[3]

COMPONENTS OF DRAG CONVEYOR CHAIN AND THEIR FUNCTION

The list of components of drag conveyor chain and their function and selection criteria is mentioned in the table -1

Table – 1: Components of Drag Conveyor and Their Function and Selection Criteria

PART	FUNCTION	CRITERIA
Plate	Bears the tension placed on the chain	Must have great static tensile strength Must hold up to the dynamic forces of load and shock Must meet environmental resistance requirements
Bush	Bears to shearing and bending stresses transmitted by the plate. Bears to shock and impact load as it strikes the sprocket teeth during the chain engagement with the sprocket	must have great tensile strength against shearing resistant to wear have strength against shock, fatigue, and compression
Pin	Bears to shearing and bending forces transmitted by the plate	needs high tensile and shear strength resistance to bending sufficient endurance against shock and wear
Nut Cotter pin Spring Clip T-Pin,Circlip	Prevent the outer plate from falling off the pin at the point of connection	May wear out during high speed operation, therefore, for this application, these parts require heat treatment
T – Flat Flight	Convey or Drag the material	Must have abrasion resistance from material to be convey Ability to wear sliding friction Tensile and shear strength
Gusset	Provide the Strength to welding joint of flight and protect bending of flights	Must have abrasion resistance from material to be convey Tensile and shear strength

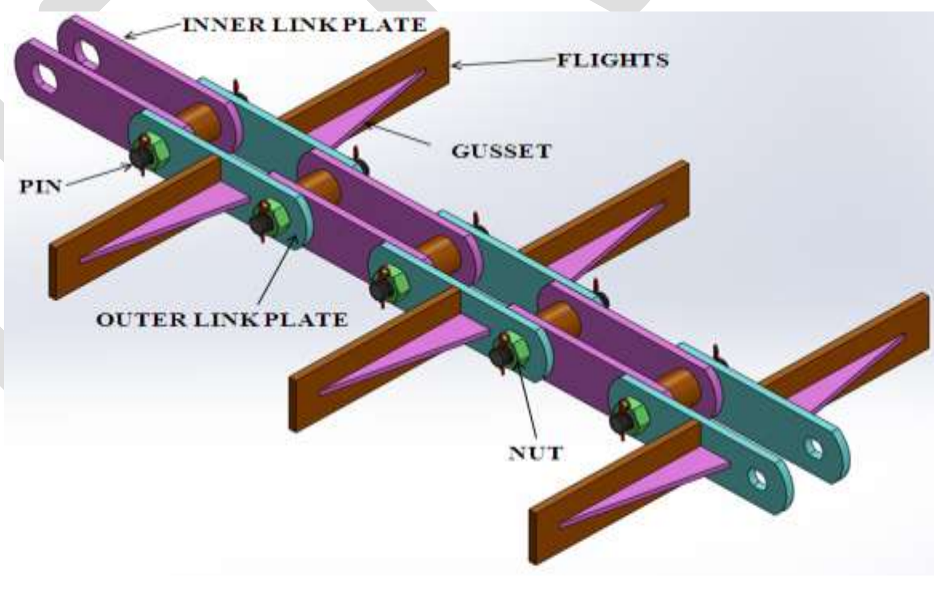

Figure 1: Components of drag conveyor chain and their function

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 2.

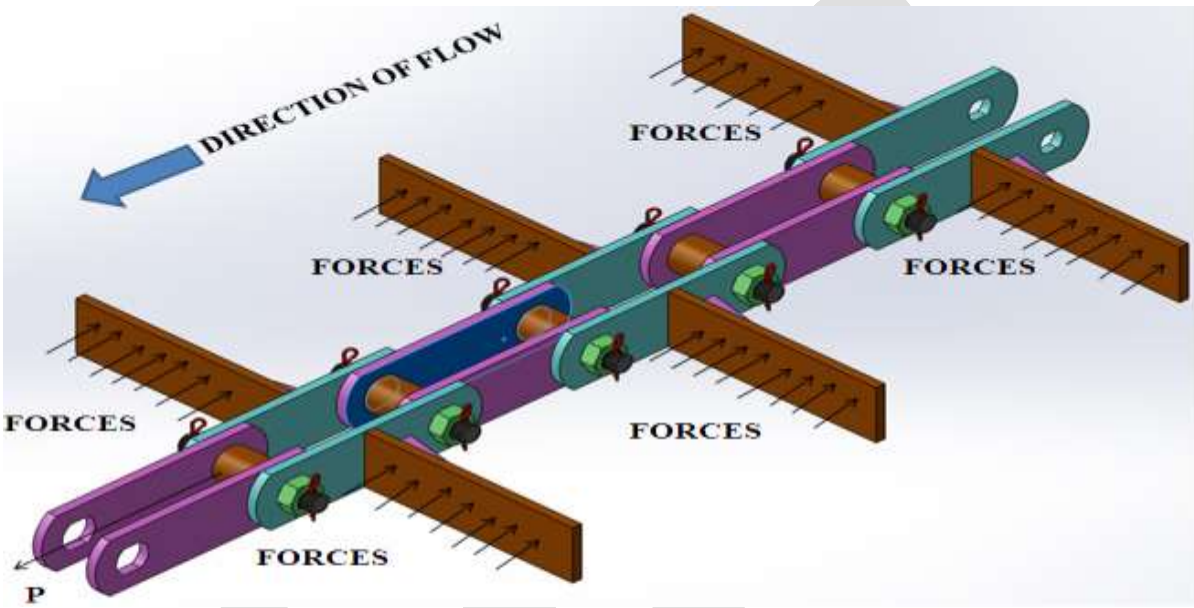

Figure 2: Direction of forces applied by material on drag conveyor chain

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 3 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.

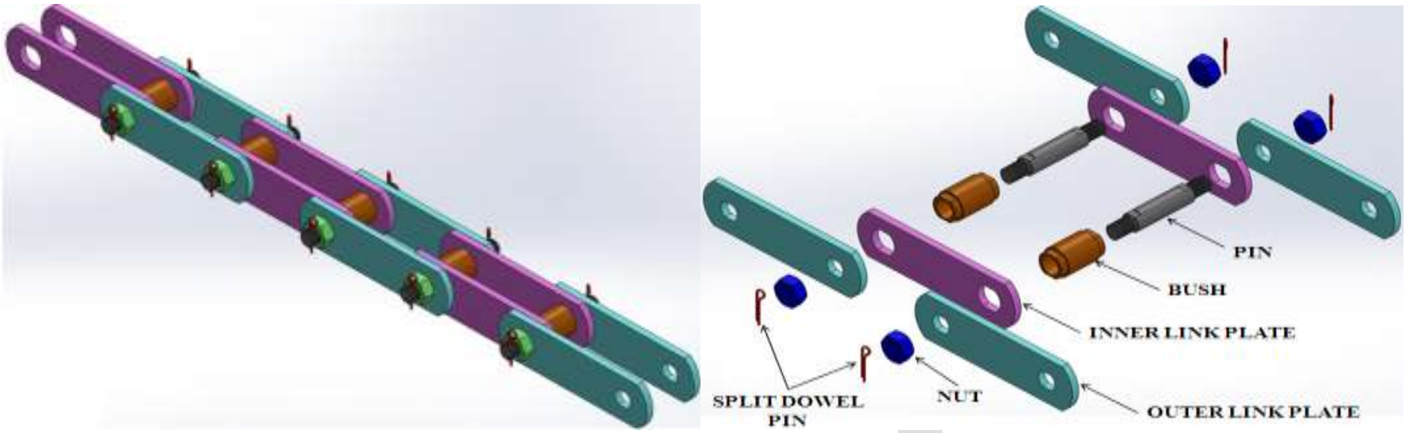

Figure 3: Assembly and Disassembly of Drag Conveyor Chain Existing Design.

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 4 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.

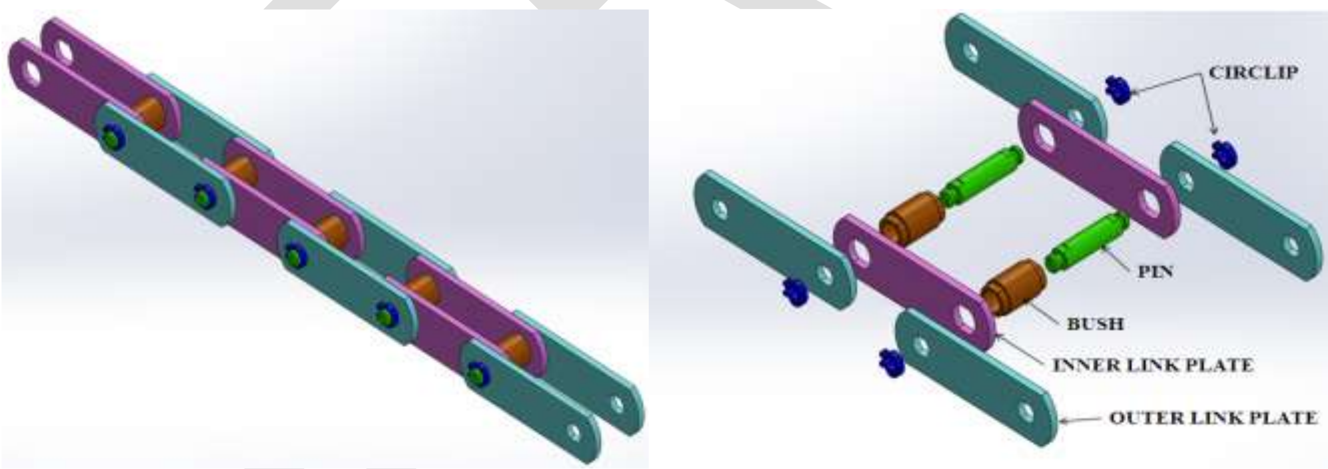

Figure 4: New design of drag conveyor chain

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 and FEA analysis of chain for finding element stress and displacement in both designs. Linear static FEA analysis of chain is being done by using HyperMesh software with OptiStruct solver. The results of comparison of chain are tabulated in table 2 and table 3.

Weight of chain

Table – 2: 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 chain

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.

Input Parameters	
Young's Modulus	2.05e + 005 2 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

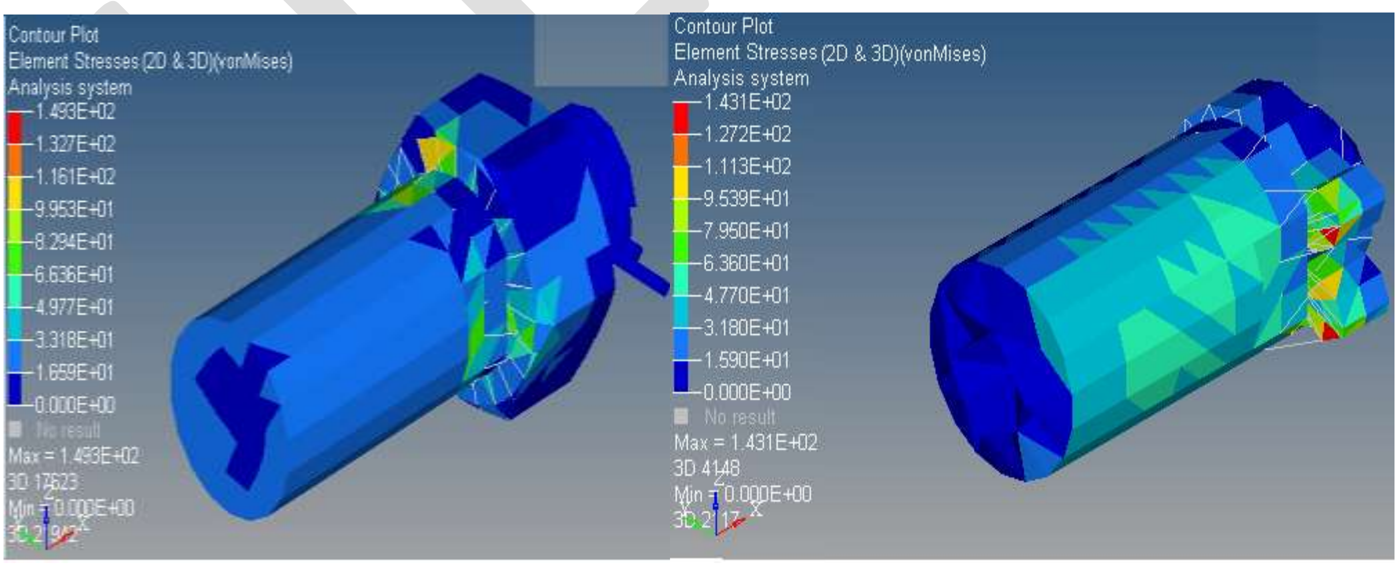

Figure 4: Element stress in pin and fastener assembly

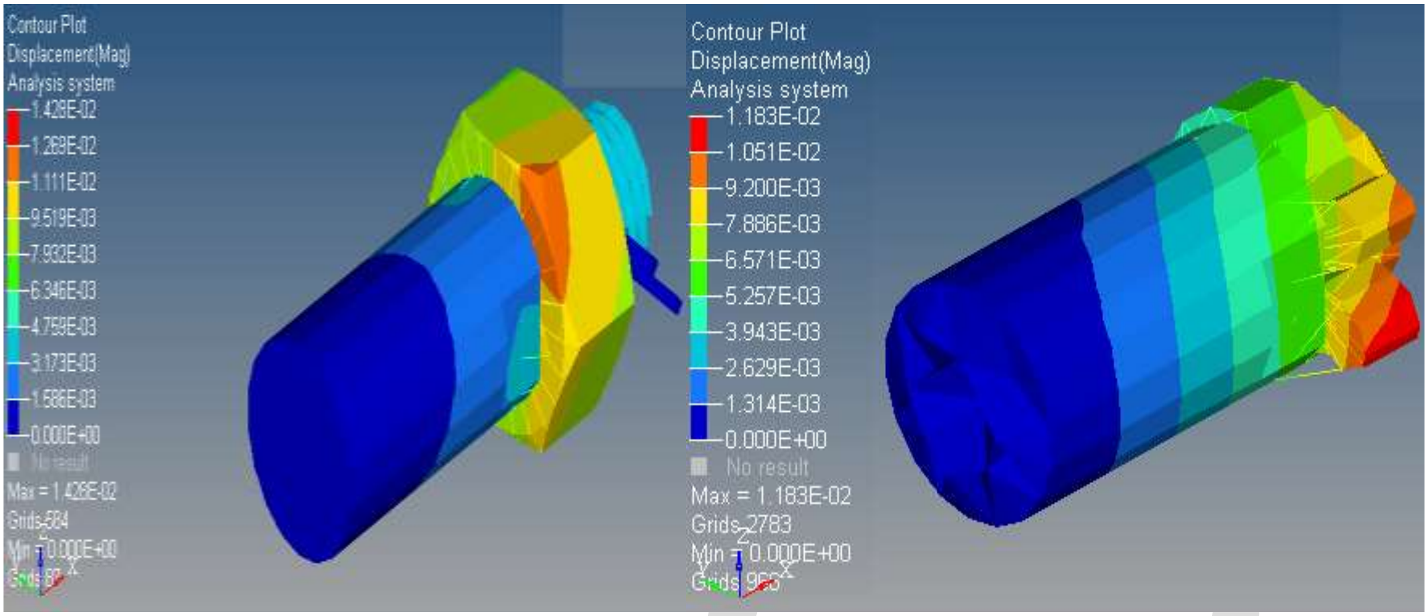

Figure 5: Displacement in pin and fastener assembly

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 displacement at 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.

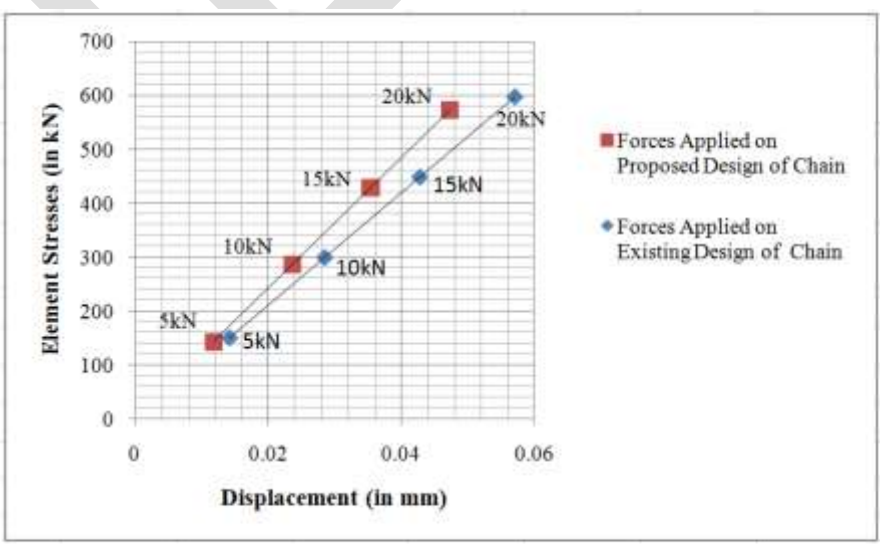

Figure 6: Graph between stress and displacement for existing design of chain and proposed design of chain at different forces

RESULTS

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

- Material saving up to 4.5% 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.

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 new design also help us in the standardization by replacing two fasteners nut and split dowel pin by single circlip. So we can say we can enhance performance of chain by implementation suggested in the proposed design.

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