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DEVELOPMENT AND ANALYSIS OF THE PAPER SUPPORT ROLLER AND SHAFT ASSEMBLY FOR EFFICIENT OPERATION IN A PAPER SLITTER-REWINDER MACHINE

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ABSTRACT

This study covers the design modification required to achieve adequate support to the paper while slitting operation is in progress. The problem was arrived at the manufacturer of digital printing papers,. Wherein, the existing paper support shaft assembly of a paper slitting machine was not fulfilling the purpose of opening the slitted gap of the paper in order to obtain the smaller paper rolls of varying sizes from a big parent paper roll of 1.5 meter. Herein, observations have been done on existing paper support assembly to identify the root cause; Design and development of modified paper support shaft assembly have been successfully performed to overcome the problem of improper slitting operation.

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1. INTRODUCTION

Basic meaning of to 'Slit' is making a narrow cut or opening in something. Roll slitting is a shearing operation that cuts a large role of material into narrower rolls. There are two types of slitting: log slitting and rewind slitting. In log slitting the roll of material is treated as a whole (the 'log') and one or more slices are taken from it without an unrolling/re-reeling process. In rewind slitting the web is unwound and run through the machine, passing through knives or lasers, before being rewound on one or more shafts to form narrower rolls. The multiple narrower strips of material may be known as mults (short for multiple) or pancakes if their diameter is much more than their width. For rewind slitting the machine used is called a Slitter-Rewinder, a slitter or a slitting machine – these names are used interchangeably for the same machines. For particularly narrow and thin products, the pancakes become unstable, and then the rewind may be onto a bobbin-wound reel: the rewind bobbins are much wider than the slit width and the web oscillates across the reel as it is rewound. Apart from the stability benefit it is also then possible to put very long lengths onto one bobbin.

The process of slitting is actually comprised of four separate and distinct components. The first two components of the process are rollover and burnish. The rollover is the initial step when the knives come in contact with the material. The knife contact area deforms the material, which in turn creates the rollover. Secondly, a portion of the edge is burnished, which is sometimes referred to as the shear zone. When looking at the edge of the strip, this is the shiny area. When the compressive forces exceed the material's ultimate tensile strength, a fracture takes place.

2. LITERATURE SURVEY

A roll slitting machine is the essential need of any manufacturing industry – metal or non-metal, as the main work of the machine is to cut down the coils into smaller pieces depending on the clients' needs. When the loops are uncoiled they are sliced to the detailed need; they are then drawn back and dispatched off to be utilized by the customer. Thus, a numerous modifications have been done in the slitting machine since the first machine was developed in order to overcome the defects and errors in the design and to obtain operating feasibility with minimum wastage and life threats. The slitting mill was a watermill for slitting bars of iron into rods. The rods then were passed to nailers who made the rods into nails, by giving them a point and head. The slitting mill consisted of two pairs of rollers turned by water wheels. Mill bars were flat bars of iron about three inches (75 mm) wide and half an inch (13 mm) thick. A piece was cut off the end of the bar with shears powered by one of the water wheels and heated in a furnace. This was then passed between flat rollers which made it into a thick plate. It was then passed through the second rollers (known as cutters), which slit it into rods. The cutters had intersecting grooves which sheared the iron lengthways.

The slitting mill was limited for heavy work especially for metal working due the high force capacity and design limitations. Further, on the concept of the Slitting Mill, the Roll slitter or Slitting machine was invented in order to process thin metals as well as non-metals. Since the invention, many inventions have been carried out for slitting operations at all the three stages – Unwinding, Slitting, Rewinding. Mr. Isao Nishimura , Ishikawa (JP), developed modifications which relates to a slitter device that includes a let - off mechanism having a let - off driving unit on which a raw - cloth roller formed by winding up an elongated sheet material in a roll shape is mounted. , a cutter in a cutter device for dividing (cutting) a sheet material has a plurality of disk - shaped rotary blades provided according to the number of divisions . In a case of a slitter device in which the cutter device is configured to cut the sheet material in cooperation with a support roll and the rotary blade around which the sheet material is wound when the rotary blade is pressed , it is necessary for the tension of the sheet material to be cut to the desired degree such that the cutting of the sheet material is appropriately performed. Conversely, if the tension of the sheet material to be cut is not the desired degree, there arises a problem that, for example, cutting defect occurs and the quality of a divided sheet material after cutting is deteriorated. [6-20]

3. PROBLEM STATEMENT

Decor papers manufacturers, primarily import high quality paper rolls of 1.5 meter length from which they obtain the required sizes via slitting operation performed on Paper Slitting Machine. While slitting the parent roll in reduced sizes, the slitted gap must be opened sufficiently by around 1 mm to obtain two different rolls on adjacent paper winding shafts.

Fig 1: a) Left Piston Bracket b) Roller bracket c) Right Piston Bracket

Old design as shown in fig 1 was consisting of piston connecting to the holding bracket and Main shaft. The roller that maintains a gap in the slitted material and its support mechanism was major concern for improper slitting.

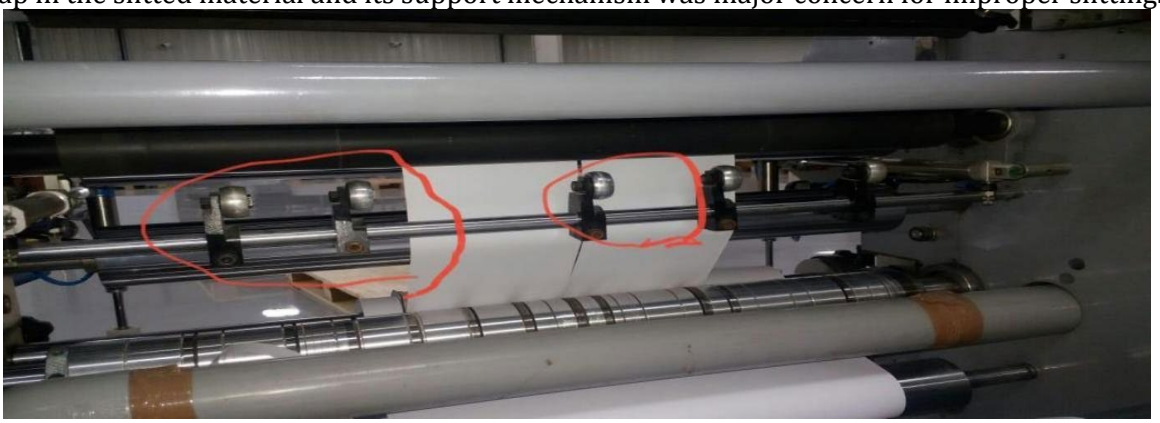

Fig 2: Old paper rewinding machine paper support system

Fig 2 shows Old paper rewinding machine paper support system. The support mechanism in the slitting machine can be pneumatically actuated in order to make it functional after overall slitting operation setting has been accomplished. Along with the advantages of the pneumatic system, such as a clean process, easy initial installation, and ease of maintenance, it also has several disadvantages. These include high operating costs, the potential for leakage, and the difficulty in identifying such leaks. Additionally, condensation and moisture can affect the system's performance. Moreover, the pneumatic system requires additional devices for speed and travel control, as well as for precise position control.

In the case of a pneumatic system, pressure builds slowly and cylinder movement may be jerky. This jerky movement comes from compressibility of the air. As air enters the cylinder, pressure builds slowly until it generates the breakaway force to start the piston moving. Because the moving force is always less than breakaway force, air in the cylinder expands. The expanding air speeds up cylinder movement, causing it to lunge forward. Here, in slitting, this jerking effect may decrease the quality of the slitted material as the support rollers may impact on the material resulting in tear of the material, dents or folds.

Also, the longer the distance between supports, the more is the chances of the beam to bend due to the effect of gravitational force and loads applied on it. Thus, it is recommended to maintain minimum distance between supports. In case of space restriction, rigid supports must be provided in addition to a larger cross-sectional area.

4. ISSUES IN EXISTING PAPER SUPPORT SHAFT ASSEMBLY

The major issue was gap of 1 mm between slitted edges of the paper is not being maintained properly - resulting in overlapping of the edges of the paper. The slitted edges of the paper were getting folded due to which paper slitting is not proper.

1. NON - SIMULTANEOUS MOVEMENT OF PISTON

When the pneumatic cylinders are actuated, the pistons are operated one after the other thereby creating jerking movement. Due to this, the roller brackets tend to hammer the roller on the paper resulting in damage to the edges of the slitted paper edges.

2. BOW OR BEND IN THE MAIN SHAFT

A slight bend has been observed on the main shaft on which the roller brackets are mounted. This might be the result of the weight of the roller brackets which are 6 Nos in total with rollers. Each roller bracket assembly included two bearings, a circlip, Aluminium bushing in which bearings are fitted, roller holding pins, Roller bracket itself, and allen bolt for tightening the roller bracket on the main shaft - In total weighs to 300Gms. Multiplying with quantity, the total weight on the main shaft equals to 1.8 Kg.

As the bend was observed, the company personal tried to remove the bend by welding a MS flat of size 10mm along the length of the main shaft. But, as the material of the shaft is MS of Diameter 25 mm, the welding had resulted in further bending of the main shaft.

3. MOVING ASSEMBLY

As the main shaft has to travel to and fro on movement of the pneumatic piston, the assembly becomes unstable. Also, on observations, it was found that the main shaft supporting brackets mounted on the piston has also undergone a slight bend as it has to support the shaft of weight 16 Kg carrying 6 brackets of weight 1.8Kg. So the total load on the shaft support bracket was 17.8 Kg.

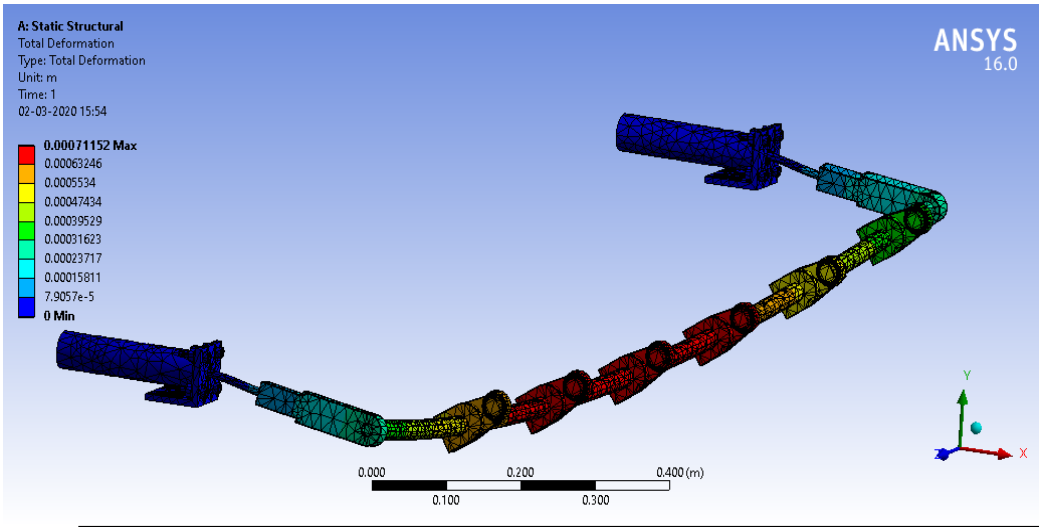

Fig 3: Existing design total deformation under static structural loading

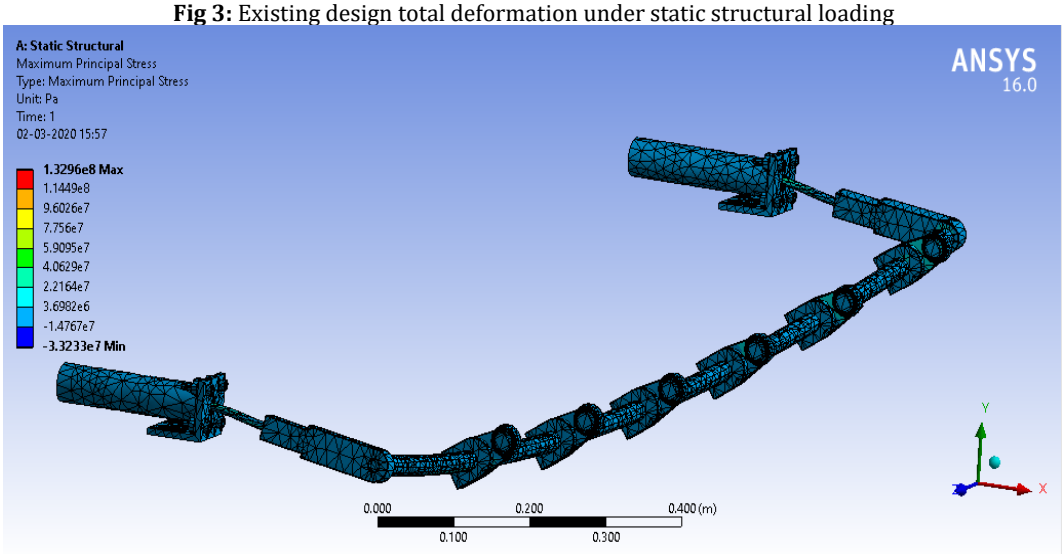

Fig 4: Existing design Maximum principal stress under static structural loading

4 BSERVATIONS STUDYING EXISTING PAPER SUPPORT SHAFT ASSEMBLY

Following observation drawn after analysing existing design

1. To make a rigid support system, for which steady - fixed support need to be designed
2. As the length of the shaft being 2000 mm supported only at the ends, cross section needs to be increased to get required strength.
3. The shaft material needs to be changed from MS to SS to get required strength

4.1 DESIGN MODIFICATIONS

After studying existing slitting machine modified design has been proposed and analysed. It is observed that jerk or hammering effect was not observed due to stationary system whereas in earlier design jerk observed. Smooth adjustment of roller brackets observed throughout the length of the main shaft due to grinding finish. Equal contact from

all the rollers can be achieved due to the shaft. Gap of 1 mm between the slitted edges achieved when the rollers are in contact with paper with slight pressure just to open the gap. No folding of slitted edges observed.

5. DESIGN OF MODIFIED ASSEMBLY

As per the observations of old design and trial and cumulative result of all the iteration stages, the old paper support shaft assembly is being modified. Fig 5 shows 3-D model of modified paper support shaft assembly with roller support. Figure 6 shows stress distribution of modified paper support shaft assembly with roller support. Red areas represent the maximum stress (0.85542 MPa) which is safe and proved by calculating equivalent principle stress as 0.9526 MPa for the paper support ,while blue areas indicate the minimum stress (5.0489e-6 MPa). Figure 7 to Figure 10 shows actual development of modified paper rewinding machine paper support system.

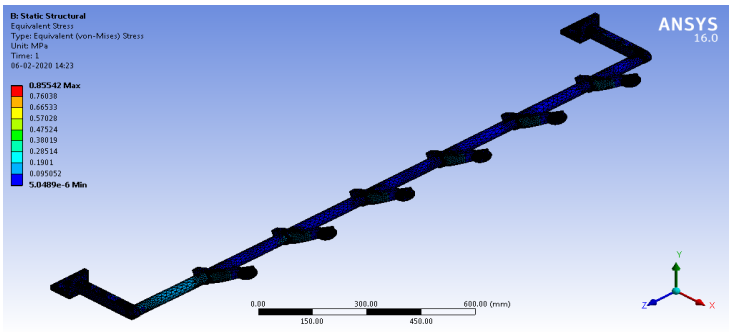

Fig 5: 3D model of Modified paper support shaft assembly

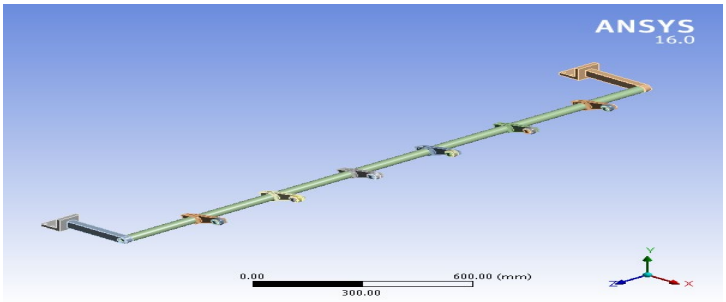

Fig 6: Static structural analysis of Modified paper support shaft assembly for Equivalent stress

Fig 7: Left Shaft Bracket

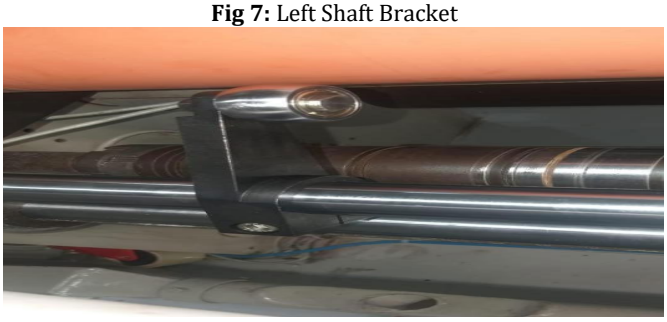

Fig 8: Roller bracket

Fig 9: Right Shaft Bracket

Fig 10: Development of modified paper rewinding machine paper support system

6. CONCLUSION

The design and development of paper support shaft assembly successfully manufactured with respect to the observations and specifications of all the iterations performed. Implemented design resolved the problem of paper tear due to jerk effect of the piston movement. This creates repeated disturbance in setting the paper supports due to paper tear off affected by the jerking movement of the shaft, this issue also eliminated. This result in saving the valuable production time, rust contamination with paper due to MS shaft is eliminated. Equal support to the paper throughout the length of the shaft is achieved, result of which, no bend has been observed on the shaft due to static – axial loading on the shaft. Cost of running the compressor for piston is eliminated, simple and maintenance free system resulted in minimum operating cost. Labour work also reduced, only operator has to set the paper support system once before slitting operation.

CONFLICT OF INTERESTS

None.

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