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Operation to Reduce Rejection in Cylinder Liners Manufacturing

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Abstract- The paper proposes introducing a new operation to reduce rejections in a recognised automotive industry. This industry manufactures cylinder liners by using the updated technologies & principles in the market. The problem lies in the operation process i.e., when machining due to compressive and shear forces by the tool on the liner , residual stresses are developed in the beneath the collar of the liner . The liners are passing the quality inspection but when the liner goes to assembly section at the customer end it fails by developing a crack beneath the collar. The main objective of this paper is to reduce the rejections for that particular reason in the cylinder liner manufacturing industry. This can be done by application of introducing a new operation in the process named deep rolling. By performing this operation the inner grains of the liner at that particular area will be aligned by the concept of cold strengthening & burnishing.

Keywords- cold working, deep rolling, manufacturing, process addition, crack elimination, burnishing, stress removal

I. INTRODUCTION

Deep rolling is a method of cold work deformation and burnishing to increase durability and design safety factors [1]. Cold working is the strengthening of a metal by plastic deformation. This strengthening occurs because of dislocation movements and dislocation generation within the crystal structure of the material. Most non-brittle metals with a reasonably high melting point as well as several polymers can be strengthened in this fashion citation needed. Alloys not amenable to heat treatment, including low-carbon steel, are often work-hardened tasks.[2] Burnishing is the plastic deformation of a surface due to sliding contact with another object. Visually, burnishing smears the texture of a rough surface and makes it shinier. Burnishing may occur on any sliding surface if the contact stress locally exceeds the yield strength of the material.

This paper is the result of our study on the problems in an automotive industry well known and leading manufacturers of cylinder liners in India. The manufacturing company has around 70 machines which are separately divided into 8 manufacturing cells. These cells are dedicated to manufacture a particular model. This company had an organisational structure and has ISO/TS: 16949 certificate.

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The company follows well advanced technologies and principles to reduce rejections and reworks but as it is a new problem a raised in the process it is must to nullify the problem & satisfy the customer to complete the process without rejections at the customer end also. So to overcome this problem, we have proposed a solution.

Our solution to this problem is to apply the concept of Deep rolling where the surface can be strengthened by performing a mechanical surface operation. In this operation a roller is made to roll on the beneath part of the roller by maintaining constant pressure for 97 seconds.

II. PRESENT OPERATING PROCESS

After the casting the liner follow 7 set of operations.
The operations are

1. Rough boring and Rough Turning.
2. Rough Computer Numerical Control Turning.
3. Fine boring.
4. Rough honing.
5. Fine computer numerical control Turning.
6. Computer numerical control grinding.
7. Final honing & cross hatching.

III. HOW THE DEEP ROLLING PROCESS CAN BE INTRODUCED

In deep rolling process forming happens cold i.e. the boundary layer is consolidated cold, below the recrystallization temperature of the material. Plastic forming induces disruptions in the lattice structure. The increased dislocation density increases the strength of the boundary zone and can thereby prevent cracking or retard the rate of crack growth. In respect of its kinematics a deep rolling process is similar to turning or milling and can be carried out by plunging for small radii feeding or with a linear feed movement. To avoid sharp gradients in the boundary layer the build-up of rolling force or pressure is prolonged. By means of this careful increase a notch effect is prevented. Because of the simple kinematics the process can be used with conventional machine tools. To understand burnishing, first look at the simple case of a hardened ball on a flat plate in the figure 1.

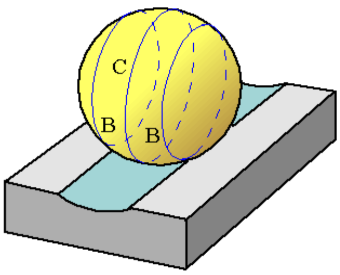


Figure 1

If the ball is pressed directly into the plate, stresses develop in both objects around the area where they contact. As this normal force increases, both the ball and the plate's surface deform. The deformation caused by the hardened ball is different depending on the magnitude of the force pressing against it. If the force on it is small, when the force is released both the ball and plate's surface will return to their original, unreformed shape. In this case, the stresses in the plate are always less than the yield strength of the material, so the deformation is purely elastic. Since it was given that the flat plate is softer than the ball, the plate's surface will always deform more.

According to Hertz, when similar maximum comparative stress is concerned, a larger rolling element results in a greater depth of penetration of the comparative stresses. The residual stresses correlate with these comparative stresses so that the shape of the rolling element has a great influence on the path of the residual stresses. With the larger rolling element therefore a greater depth of penetration is always caused by rolling compared to shot peening where significantly smaller peening material is used. The depth path of residual stresses and hardness has a significant effect on the service life of a component.

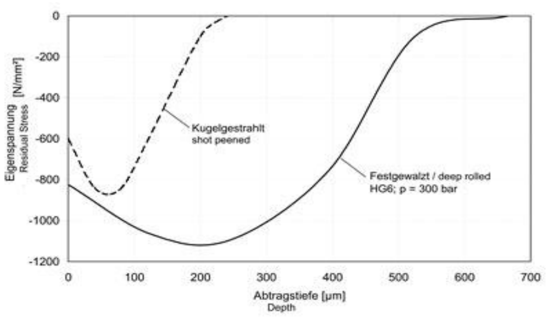


Figure 2

In order to achieve optimum results the path of the load induced stresses must also be observed. Adverse conditions in the boundary layer can result in the crack exit is deflected from the area of the surface to below the surface. This is not desirable since there is no external sign to indicate a failure.

As a result of plastic forming of the boundary layer at temperatures below the recrystallization temperature cold work hardening takes place when deep rolling. When plastic forming takes place layers of atoms slide past each other. In the microstructure the sliding is impeded on the grain boundaries. At these points the space lattice is distorted and results in prevention of sliding. Cold work hardening leads to a greater number of distortions of the space lattice. These prevent further sliding of the material when further loading takes place. That means that a cold work formed zone will be hardened and brittle. Further load will then result in fracture rather than sliding. The embrittlement which for the forming of sheet metal for example can become critical does not represent a problem for deep rolling since the cold hardening only occurs in the boundary layer. However, raising the elastic limit and tensile strength in the boundary layer contributes significantly to increasing service life.

IV. INTRODUCING DEEP ROLLING OPERATION IN THE PROCESS

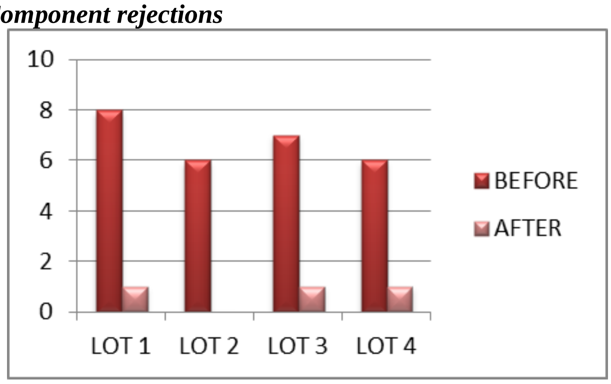
In the above mentioned series of operations the main operations ends with fine computer numerical control turning i.e., only in those operations only the liner will be subjected to residual stresses so now we can apply deep rolling process next to it (Computer numerical control turning) so that when computer numerical control grinding operation is performed the failure the liner can be detected, because the grinding operation is done on the collar. Therefore we can perform deep rolling in that sequence. The new sequence order is

1. Rough boring and Rough Turning.
2. Rough Computer Numerical Control Turning.
3. Fine boring.
4. Rough honing.
5. Fine computer numerical control turning.
6. Deep rolling.
7. Computer numerical control grinding.
8. Final honing & cross hatching.

V. RESULTS

To illustrate the difference between the present method and proposed method the component life and the component rejection due to that particular reason are graphically shown

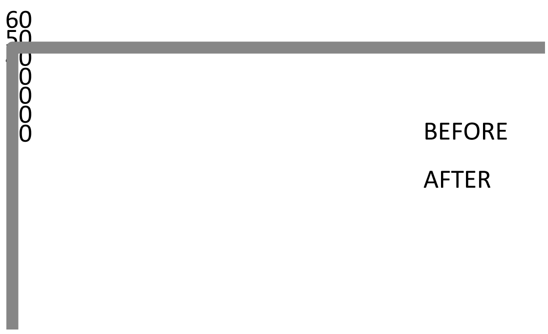
Component rejections



Here on the X-axis we have lot number and on the y- axis we have number of rejection due to crack at the collar. In the after case we can notice that some 1 rejection had appeared that rejection had happened not because of operation but operator and those after rejections are in house rejections.

Component life

If we take the life of the component in terms of months it is used by making an assumption that all are working under same conditions definitely we can imagine a large variation of increase in life after deep rolling process The possible graph would be in this manner



VI. CONCLUSION

This paper gives a solution to a common problem for cylinder liner manufacturers. By adding deep rolling process we can eliminate the rejection due to crack beneath the collar. It increases the life of the liner and reduce rejections in fitment area.

VII. ACKNOWLEDGEMENTS

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