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Prof. Dr. M. A. Shama

1- "A Design Study of a Numerically Controlled Frame Bending Machine", RINA. (UK-1965), Shama, M. A. and Miller, N. S., (90%)

2- "Plastic Bending of Short Mild Steel Beams", Bull. of the Faculty of Engineering, Alexandria University, (Egypt-1965), Shama, M. A. (100%)

3- "Behavior of Short Mild Steel Beams Bent into the Plastic Range of the Material" Bull. of the Faculty of Eng. Alexandria University, (Egypt-1967), Shama, M. A., (100%)

4- "The Impact of Application of a Numerically Controlled Plate Forming Machine on Shipyard Production" Bull of the Faculty of Engineering, Alexandria University, (Egypt-1968), Shama, M. A., 100%)

5- "Numerical Control of Plate Forming and Associated Problems", Shipbuilding and Shipping Record, Jan. (UK-1970), Shama, M. A., (100%)

6- " On the Calculation of Cold Forming Residual Stresses", Bull., Of the Faculty of Engineering, Alexandria University, Vol. XI. (Egypt-1970), Shama, M. A., (100%)

7- "Cold Forming Residual Stresses and Their Effect on the Accuracy of Post – Forming Operations", European Shipbuilding, No.2, and No. 3, Vol. 19. (Norway-1970) Shama, M. A., (100%)

8- "On the Calculation of Cold Forming Residual Stresses", Schiff und Hafen, (Germany-1974), Shama, M. A., (100%)

Numerical control of plate forming and associated problems

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IN THE PAST few years, the definition of the hull shape in a mathematical form has been successfully achieved. As a result, it has become possible to define any part of the ship's hull mathematically and therefore very accurately. In order to make use of this achievement, numerically controlled machine tools, for the production of the different parts of the ship-hull, have been the subject of much research work. The first achievement was the numerically controlled flame cutters which are developed to a satisfactory degree of operation and are now in use. The second application of the numerical control technique was to the frame bending machine.

The impact of using these two machines on control of shipyard production, planning and economy will be much improved when plate forming operations are also controlled numerically. This will eliminate completely the mould loft and the use of templates in addition to dispensing with the skilled labour required for these operations. However, the largest savings are likely to accrue from increased accuracy of individual parts which will reduce assembly times and rectification costs.

Is it necessary to design and develop a numerically controlled plate forming machine? The argument is based on different factors, mainly, the impact of application of computers to the shipbuilding industry, the impact of application of plate forming machines on flow line production, the number of plates required to be bent to two and three dimensions, the utilisation factor of the machine, the accuracy required during the plate forming operation and its impact on the size of the shipyard.

Forming techniques suitable for numerical control

Not all plate forming techniques currently in use can have feasible and direct practical application for the design of a numerically controlled plate forming machine. However, the following techniques, after being developed to a satisfactory degree of operation, are believed to be the most suitable for the development of such a machine:

1. Hot-line forming
2. Press forming using an infinitely variable die
3. Squeeze forming

In hot-line forming, the heating source could be made to move on certain prescribed contours calculated in advance in such a way that a certain system of internal stresses is imposed in the plate material. This internal stress system will be such that the plate will "distort" or form to the required shape. It is possible that the numerically controlled flame cutting machine could be used for this purpose.

In the case of press forming, a suitable die is required to withstand the high forming forces. The shape of the die should take "spring back" effect into consideration. It should be realised that it would be very expensive and uneconomical to form a die to suit each curved plate. This problem, however, could be solved by designing an infinitely variable die which could be controlled to take any required shape. The design of such a die could be based on the idea of the telescopic rig shown in Fig. (1), or on the method of forming shapes for some rocket parts. In Fig. (1), the height of each ordinate, i.e. z, is adjusted such that the equation to the surface given by $z = f(x, y)$ is satisfied. This could be achieved in the z-x plane by the equation $z = f(x)$ and in the z-y plane by the equation $z = f(y)$. It is believed that it is feasible to design a matrix of screw or hydraulic jacks which are numerically controlled in the (z-x) and (z-y) planes.

Squeeze forming

In the case of squeeze forming, the required curved shape could be achieved by applying a very high concentrated force on a localised area. A system of internal stresses will be induced in the material in such a way that the plate should attain a certain amount of curvature. When the applied force is controlled and moves on certain calculated contours, ship plates could be numerically formed to double curvature. Poissons' ratio effect will induce orthogonal curvature which should be taken into account in the subsequent contours. The final shape of the plate is the resultant of the

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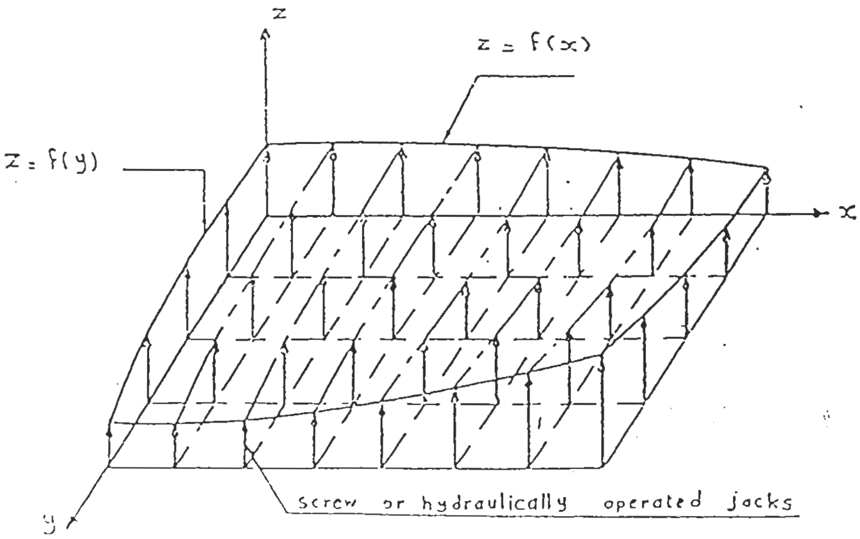
Fig. 1. A telescopic rig used with press forming



accumulative effect of each squeezing run.

This method of forming requires a numerically controlled measuring and checking system. Discrepancies with the required plate shape could be corrected by repeated squeezing on certain contours over the plate surface.

Before designing the mechanical and control parts of a numerically controlled plate forming machine, the above suggested techniques should be fully developed theoretically and experimentally, so that they can be satisfactorily used in the numerical control of plate forming.

It should be noted that, apart from the mechanical, control and measuring problems associated with the design of a numerically controlled plate forming machine, the introduction of such a machine into the production line of ship plates may induce some additional requirements in the design and operation of the machine. Therefore, in order to make the design of a numerically controlled plate forming machine an economical solution, the impact of introducing such a machine, in the flow line production, on the sequence of ship plates operations, should be investigated. Furthermore, the capacity, speed of production and versatility of the machine may be influenced by other machines in the production line and should be determined from economical considerations.

Impact on sequence of ship plate operations

The different plates must be brought to the workshop in the correct sequence. The various working operations are usually planned in such a way that bottlenecks are eliminated, idle time and handling operations are reduced to minimum; since about 60 to 80% of the working time in the plater's shop is spent in the handling and transport work. As plates comprise about 80–85% of the material weight of a vessel (i.e. about 65% of the handling time), plates will be responsible for the greater part of the handling costs which should be made as low as possible.

The probable sequence of operations of ship plates in a shipyard means that between 7–10 handling operations are required. However, this number of handling operations can be reduced by using automatic conveyors. Buffer areas are necessary at various stages to allow for the difference in speeds of the various machines and the necessary times for the different operations. Much time is lost in handling in and out of the buffer areas and therefore considerable effort should be made to reduce these areas by matching the speeds of operations of all the machines so as to give a continuity of flow. Marking operations can be performed by using either full-scale templates or by optical projection techniques.

Ship plates are usually divided into three major categories, namely, plates having straight edges, plates having curved edges and miscellaneous plates. Each category has its own route in the production line.

All the required information for controlling the production line in a proposed flow-line production comes from the design office. The latter performs all the necessary calculations and supplies the required data for machine tool control, marking, etc. It is proposed that a single machine for plate straightening, shot-blasting and priming may be designed to perform simultaneously these operations. It is believed that the design of such machine is not a formidable task.

In the proposed production line, single curvature plates are shaped on a bending roll while three-dimensional plates are formed by any conventional method. For both machines, templates can be obtained from the numerically controlled frame bender. In this way, the mould loft could be completely dispensed with. This proposed system may be considered as an intermediate stage between the traditional shipyard and the anticipated computer controlled shipyard.

In another proposal a numerically controlled plate forming machine is introduced into the production line for executing all plate forming whether to single curvature or double curvature. In this case, no template whatsoever will be required for the production of any part of the ship. Also by introducing numerically controlled marking, which is successfully used in some Scandinavian shipyards, for both flat and curved plates, the production line will be more compatible and could be fully controlled by the design office.

Impact on economy of shipyard production

If the main shipyard operations, namely, flame cutting, frame bending, marking and plate forming, can be done numerically then all lofting, scrieve boards and templates can be completely eliminated. This would produce savings in material, space, labour, material for templates in addition to the savings resulting from increased accuracy.

The savings in labour are difficult to estimate. Although fewer men will be employed for operating the numerically controlled machines, planning, programming and data preparation may require more qualified people with higher salaries. The savings resulting from increased accuracy are impossible to forecast precisely, but a considerable saving in material is expected with a consequent reduction in scrap. Since the computer controlled flame cutting machine has resulted in a savings of 5-10% in the amount of weld metal deposited, it will be expected that greater savings will be achieved in the case of plates, as the gap between the plates and the mating frames will be reduced considerably. However, it is in the reduction of rectification costs and fairing on the berth that the biggest savings should come.

The introduction of a numerically controlled plate forming machine will certainly save some handling operations and buffer areas. In addition, the efficiency of the machine will be much improved when a numerically controlled marking machine is also used.

The utilisation factor of a numerically controlled plate forming machine, if it is used only for forming ship plates, will be very low. Unless the shipyard output is relatively high, this machine will make the forming of three-dimensional plates a very expensive operation. However it should be realised that our interest is in the final costs of the ship and not the individual costs of every operation. The savings through intergrating all operations in the shipyard with the design office may be much higher than the increased costs of forming ship plates. In addition, this machine could be used for forming three-dimensional plates for submarines, pressure vessels . . . etc.

Further, it should be noted that the size of the shipyard (determined either from the tonnage launched per year or from the number of ships launched annually) has a great effect on the economics of curved plate forming using a numerically controlled plate forming machine.