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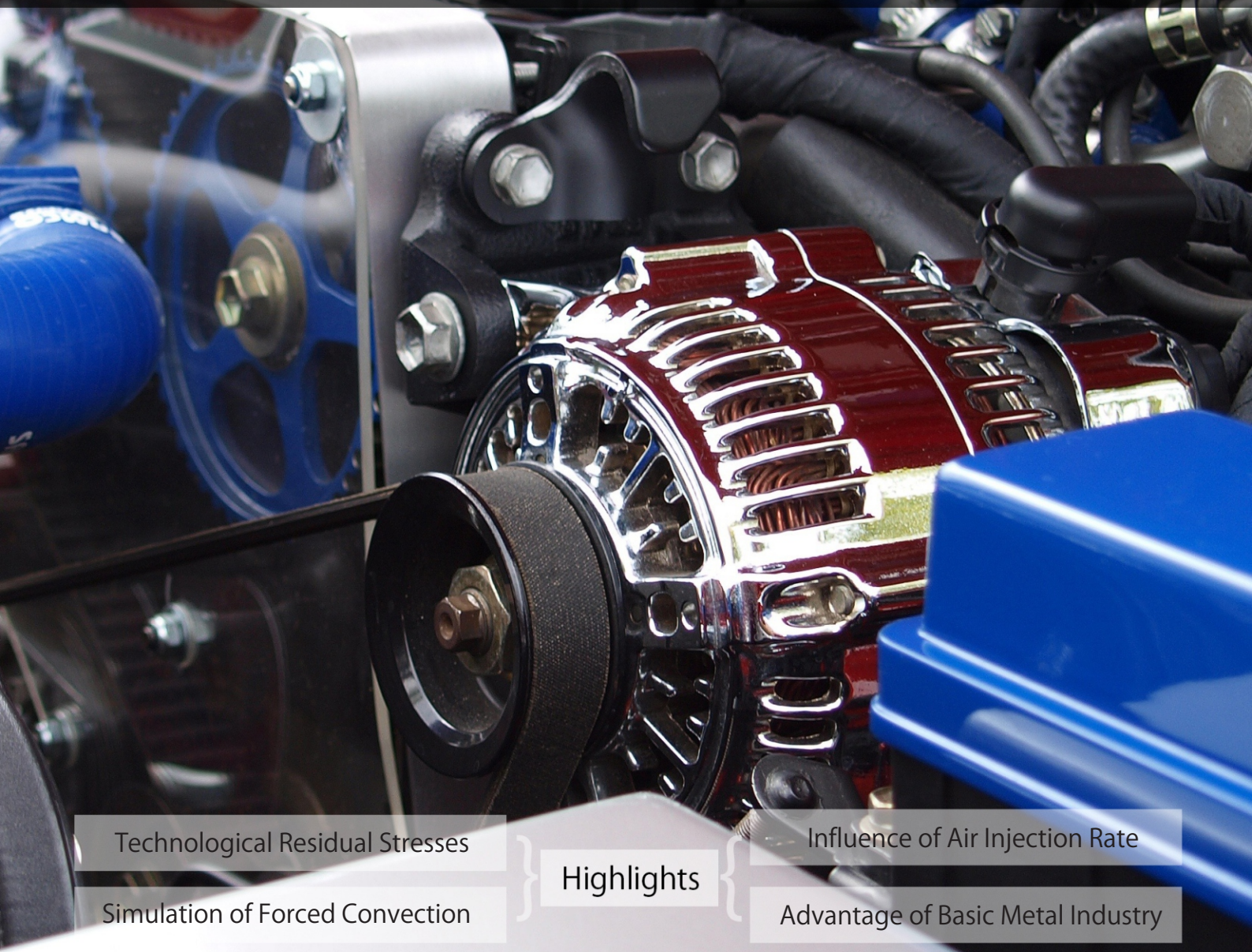

Technological Residual Stresses

Simulation of Forced Convection

Highlights

Influence of Air Injection Rate

Advantage of Basic Metal Industry

Discovering Thoughts, Inventing Future

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Dynamic Fracture Process during Three-Point-Bending Impact on Polymethyl-Methacrylate Beams

By Wu Zhou, DahsinLiu, Hoa XNguyen & Wei Huang
Michigan State University

Abstract- Dynamic fracture process in polymethyl-methacrylate (PMMA) beamshave been investigated during the three-point-bending impact tests at different imapct velocites, conducted in a drop-weight impact tower instrument. The impact-induced crack initiation and propagation have been recorded with a high-speed camera, to determine the instantaneous fracture length and crack velocity during impact process. The beam deformation and displacement fields were extracted and analyzed by using the digital image correlation (DIC) thechnique during the impact. The impact loading history has been recorded with a load cell attached to the dropping weight. Thewhole experimental studyis a suitable technique to determine the influence of the impact velocites (impact energy) on the dynamic fracture initation and propagation at different crack speeds.

Keywords: PMMA; three-point-bending impact;dynamic fracture; crack velocity, DIC.

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Dynamic Fracture Process during Three-Point-Bending Impact on Polymethyl-Methacrylate Beams

Wu Zhou [α], DahsinLiu [σ], Hoa XNguyen [ρ] & Wei Huang [ω]

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Keywords: PMMA; three-point-bending impact;dynamic fracture; crack velocity, DIC.

I. Introduction

Dynamic fracture in structural materials is a significant issue because it concerns the failure of structural materials in their dynamic service. Impact is one of the most common dynamic loading forms but complicated since the material properties and failure behaviors are complex in dynamic situation. The dynamic fracture problems have been studied experimentally [1–3] and numerically [4,5]. Joudon[1]studied the dynamic stress intensity factor by using a strain gauge method associated with high speed cinematography on a three-point-bending test with specimens made of M21 epoxy resins. Cramer[2]conducted dynamic fracture experiments using boron-doped silicon single crystals followed by cleavage fracture with the propagation of a faceted crack front with amorphous materials. Owen[3]studied the critical dynamic stress over a range of loading rates of 2024-T3 aluminum sheets ranging in thickness from 1.63-2.54 mm.The dynamic fracture process in three-point-bending beams made with isotropic polymer [4] and orthotropic composite materials [5] have been numerically simulated with peridynamics.

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Fracture in PMMA have also been studied. Takahashi [6]investigated multiple dynamic fracture parameters such as the dynamic stress intensity at thecrack tip as well as crack velocity and acceleration. They analyzed the initiation and propagation behavior of the crack of thin PMMA sheet under tensile load. Lataillade [7]studied the mechanical behavior of PMMA under various loading rates as well as the properties of the polymer at high rates of strain. Their research identified the relationship between Young's modulus, yield stress and fracture toughness of PMMA and tensile loading rates. On the other hand, Loya [8]performed quasi-static three-point bending test on PMMA beams and recorded the crack-front propagation process throughout the specimen thickness. The crack-lengthand the average steady crack propagation were extractedand studied. In a more recent study, Huang[9] adopted a different technique, dynamic semicircular bend testing, and performed fracture testing on PMMA specimen with split Hopkinson pressure bar. Their study determined the fracture velocity under different loading rates as well as surface fracture toughness and its relationship with fracture energy.

However, the impact-induced dynamic fracture process in PMMA with precise record of crack propagation and speed has rarely been studied before, especially the fracture caused by impact with different velocities. In the former studies, therecording time step period is relatively long. For example, only the average crack velocity for the whole fracture can be obtained. To better understand more detail dynamic fracture process, including the beam deformation and crack propagation, the more precise experimental investigation in more precise time steps is essential.

In this paper,the impact-induced dynamic fracture process in PMMA beams has been investigated. The experiment was conduceted with a drop-weight tower instruments. During the impact test, the impact loading history has been recorded by a load cell attached to the bottom of the dropping weiht. The impact process was recorded the with a high-speed camera at the time resolusion of about 15 microseconds. The impact-induced crack initiation and propagation have been extracted fromthe images recorded with the high-speed camera, to determine the instantaneous fracture length and crack velocity during

impact process. The beam deformation and displacement fields were calculated and extracted by using thethe digital image correlation (DIC) thechnique. The fracture in beams subjected to different impact velocities have been compared and analyzed.

II. Experimental

a) *Experiments setup*

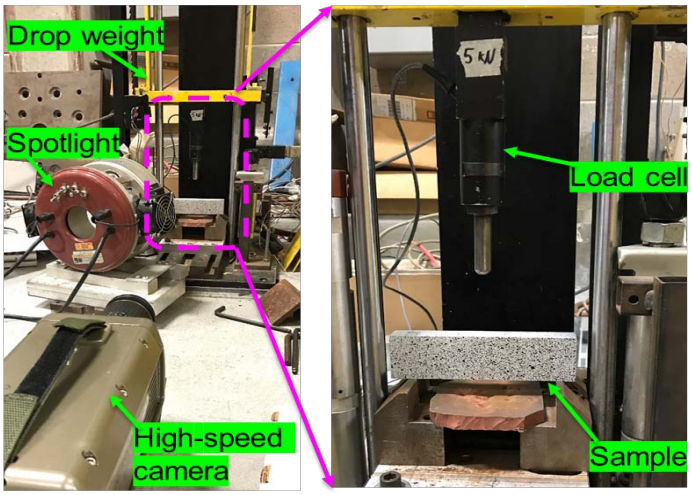

Figure 1: Drop weight impact experimental setup

The experiment was conducted by performing a three-point-bending impact test on a single-edge-notched PMMA specimen by using a drop-weight impact tower as shown in Fig. 1.The dropping weight was located above the PMMA sample and set free to drop onto the sample surface. Three impact velocities (1, 2, and 3 m/s) were achieved by dropping the weight from three different heights. To monitor the force applied during the experiment, a load cell was attached to the bottom of the dropping weight, which is used to record the loading signals during the impact process. The signals from the load cell then can be amplified by an amplifier, then displayed and recorded with an electronic oscilloscope provided by National Instruments. A high-speed camera was placed perpendicular to the vertical surface of the specimen to record the video of the impact process, which can be used to extract the crack propagation details and the corresponding displacement fields at different time steps.

The sample beam is made with PMMA (purchased from McMaster-Carr) with the length of140*mm*, thewidth of38*mm*, and height of 25.4*mm*. A notch of 16*mm* was initially made in the center of the bottom edge of the plate as shown in Fig. 2.

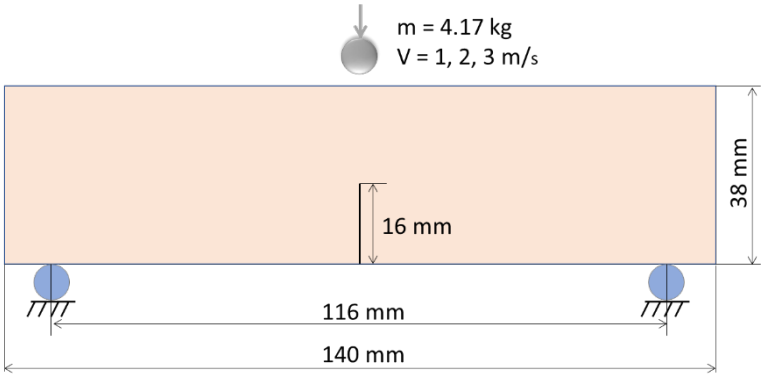

Figure 2: Impact experimental setup of PMMA beam

b) *Displacement field extraction with digital image correlation (DIC) method*

The DIC method is an optical method of experimental mechanics that can be used to measure and calculate the displacement, deformation, and strain field of the objective samples during mechanical testing[10–12].White background painting with evenly located black speckles painting was sprayed on the surface of the samples for the DIC testing. The size of the black painting speckles and the appropriate

distances between each speckle can be determined by the suggestions in[13].A fully prepared specimen surface was shown in Fig. 3.The camera was set to focus on the crack propagation region on the specimen. The resolution of the camera was 256 x 256 pixels, which correlated to the square area at the center of the specimen.A sequence of images were extracted from the video with time incremental of 5 milliseconds. The images were then inputted into software GOM correlate for displacement field and crack propagation analysis.

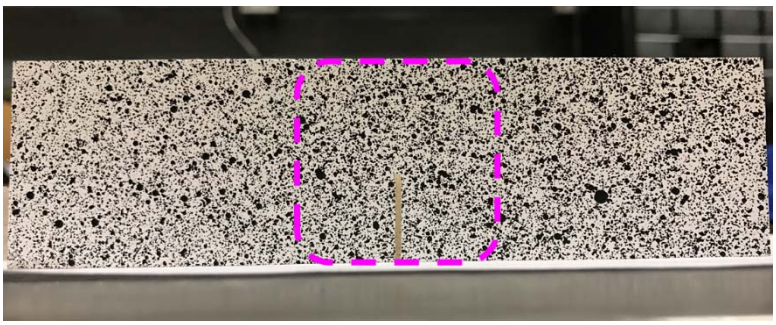

Figure 3: PMMA beam surface preparation for DIC

Toanalyze the imagesof impact process withGOM correlate software, a surface component was created at first. Emphasizing on the granularity of the sample, a surface component of 37 pixels was chosen, with a point distance of 18 pixels. The area of interest was also selected by using the Select/Deselect Polygon tool to include the crack propagation region. The original notch tip and the crack tip at each time step can be located in the images with GOM, the absolute crack propagation distances can then be directly extracted with GOM

III. Results and Discussions

a) Impact force on PMMA beam

The impact loadingswere extracted from the signals recorded with the load cell. The loading record resolution was set as 10μs.The force histories of impact processes with different impact velocities are presented in Fig. 4.In the figure, the impact force history at different impact velocities as v=1, 2, 3 m/sare presented separately with different marked curves.For impact with different velocities, similarly, the force curves initiate from zeroonce the impactor (loadcell) contact the top surface of the sample,and rise till the maximum values. The force then drops suddenly till even negative values, which indicate the loadcell recording of the reflection of the impact stress wave.However, the peak values of the impact force at different velocities are different. The peak force for impact at 3 m/s is the largest and 1 m/s thelowest. The crack initiates at the time of the peak impact force and propagates till the fracture, as shown in Fig. 5, Fig. 6, and Fig. 7.

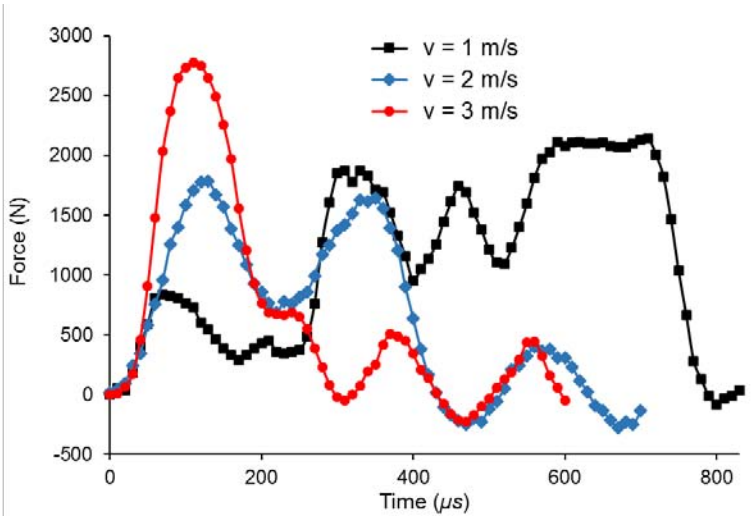

Figure 4: Force history of impact processes with different impact velocities

b) Impact fracture process

The impact fracture process in PMMA beam with the corresponding displacement fields have been presented in Fig. 5, Fig. 6, and Fig. 7, with the impact velocities at 1 m/s, 2 m/s, and 3 m/s respectively.In Fig. 5, the fracture initiates at 630 μs after the dropping weightcontacts the top surface of the PMMA beam, which means the loading time is 630 μs till the crack

initiate from the tip of the original notch. The crack propagations from the initiation at 630 μs, to 690 μs, till 780 $\mu s$are presented in Fig. 5, with the crack tip marked with the white arrows. During the fracture process, as the crack length increases, both the displacements in x and y directions increase correspondingly. The detail displacement field contour can be found in Fig. 5 with the specific color bar. Displacements fields are symmetric to the vertical line of the original notch. The change of the color in the displacement contour indicates the deformation process of the beam during the impact process, which lasts as short as round 150 μs.

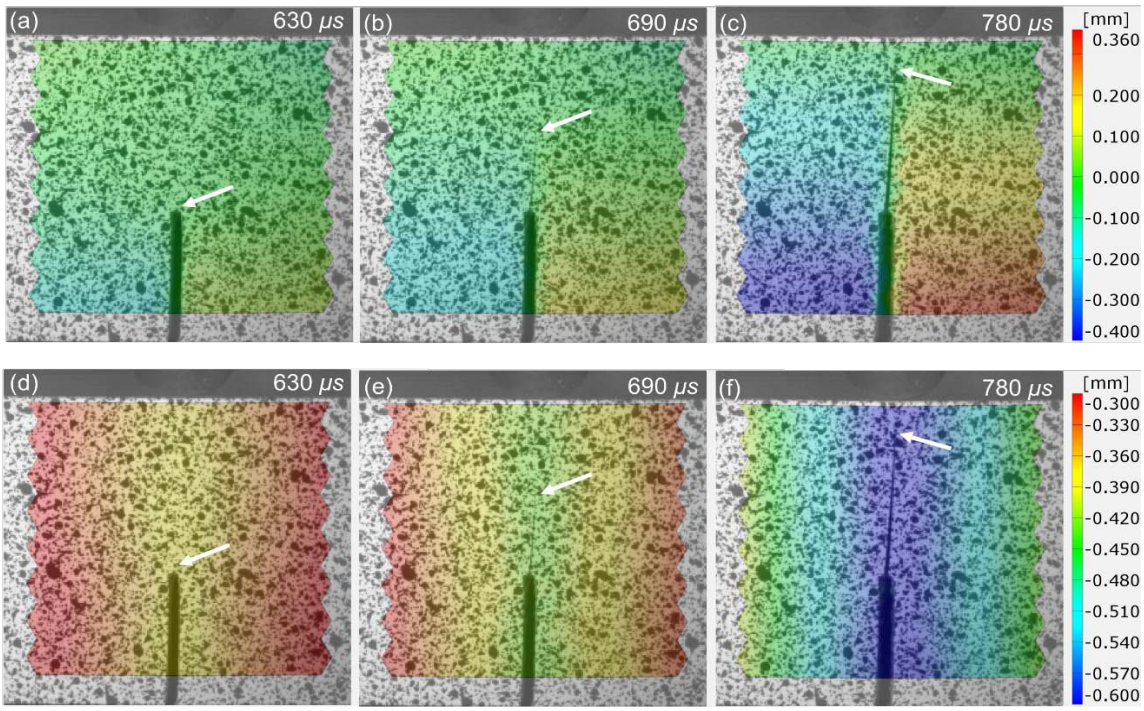

Figure 5: Crack initiation and propagation at different time steps, with the corresponding displacement fields (displacements in x direction: (a), (b), and (c); displacements in y direciton (d),(e), and (f))in the PMMA beam after the impact at the velocity of 1 m/s. (The crack tips are marked with the white arrows)

Once the dropping weight reaches the top surface of the beam, the beam is subjected to an impact loading and starts to bend due to the simply supported boundary conditions at the bottom surface. During the impact bending process, the tensile stress concentration increases at the tip of the original notch. The crack initiates to propagate once the stress intensity factor reaches the critical value (fracture toughness).

Fig. 6 shows the fracture process in PMMA beam with the impact at a velocity of 2 m/s. The fracture initiates at 285 μs after the dropping weight contacts the top surface of the PMMA beam. During that time, the dropping weight subject impact loading at the middle of the top surface of the beam, which causes the beam bending with the increase of the stress concentration at the crack top. The crack propagations from the initiation at 285 μs, to 345 μs, till 435 μs, with the crack tip marked with the white arrows in Fig. 6. Similar to the impact at a velocity of 1 m/s, during the fracture process, as the crack length increases, both displacements in x and y directions increase correspondingly. The detail displacement field contour with color bar can be found in Fig. 6. Displacements fields are also symmetric to the vertical line of the original notch. The change of the color in the displacement contour indicates the deformation process of the beam during the impact process, which lasts during the time period as short as about 150 μs.

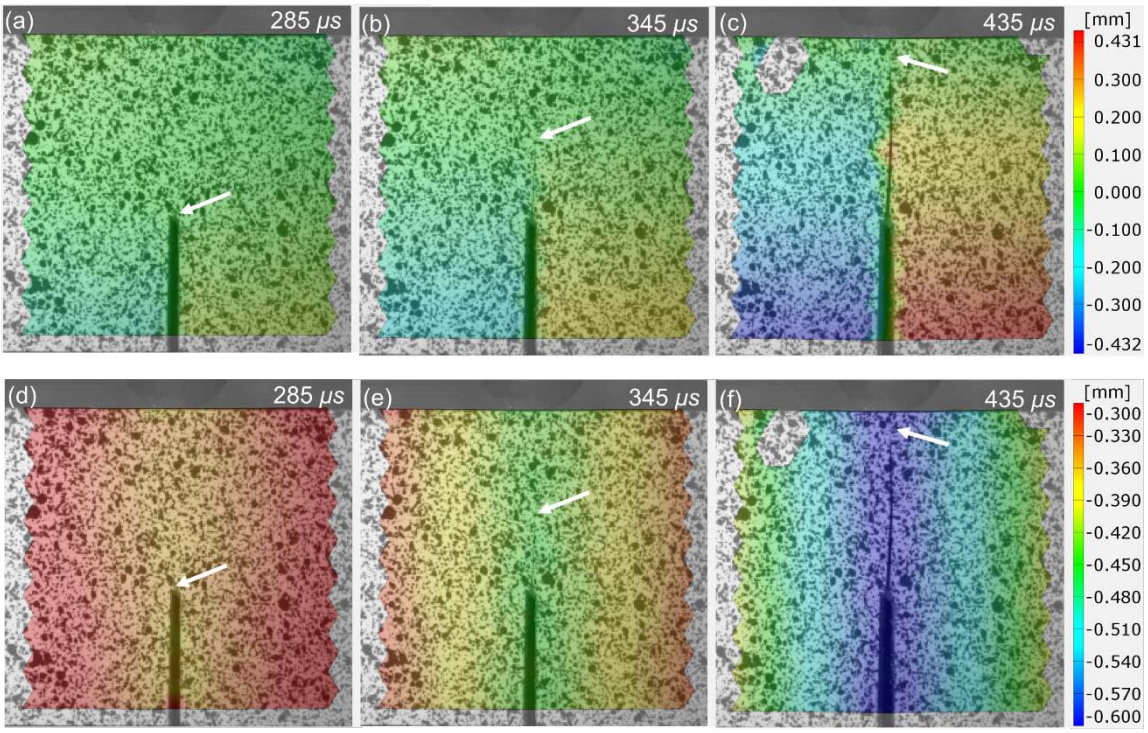

Figure 6: Crack initiation and propagation at different time steps, with the corresponding displacement fields (displacements in x direction: (a), (b), and (c); displacements in y direciton (d),(e), and (f))in the PMMA beam after the impact at the velocity of 2 m/s. (The crack tips are marked with the white arrows)

Fig. 7 shows the fracture process in the PMMA beam with the impact at a velocity of 3 m/s. The fracture initiates at 110 μs after the dropping weight contacts the top surface of the PMMA beam. The crack propagations from the initiation at 110 μs, to 170 μs, till 260 μs, with the crack tip marked with the arrows in Fig. 7. Similarly, during the fracture process, the crack length increases, and both the displacements in x and y directions increase correspondingly. The detail displacement field contour with color bar can be found in Fig. 7. Displacements fields are also symmetric to the vertical line of the original notch. The displacements contours indicate the deformation process of the beam during the impact process, which lasts during the time period as short as round 150 μs too.

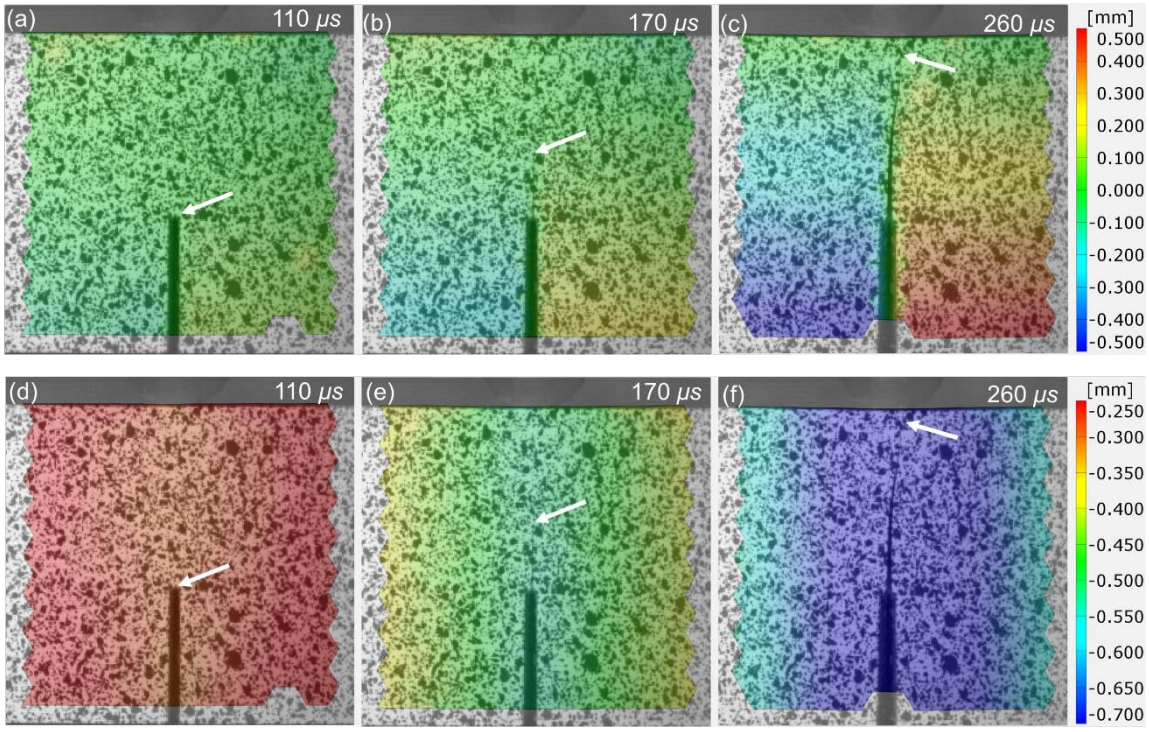

Figure 7: Crack initiation and propagation at different time steps, with the corresponding displacement fields (displacements in x direction: (a), (b), and (c); displacements in y direciton (d),(e), and (f))in the PMMA beam after the impact at the velocity of 3 m/s. (The crack tips are marked with the white arrows)

The crack initiation and propagation length history in PMMA beams subjected to impact at different impact velocities are shown inFig. 8. During the impact process, the time step when the dropping weight contacts the surface of the beam is set as 0. The crack initiation time for PMMA beam subjected to impact at velocities of 1 m/s, 2 m/s, and 3 m/s are 635 μs, to 265 μs, and 110 μs, respectively. Obviously, the loading time before the crack initiates is much longer for higher impact velocity, shorter for lower impact velocity. The cracks propagate till 20 *mm* within about 150 μs, but with adifferent slope of the length curves, which means the crack velocities are different, as shown inFig. 8.

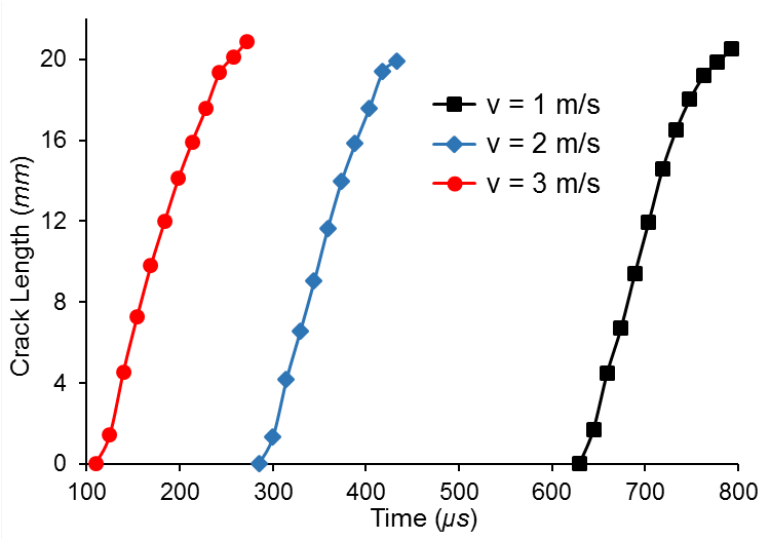

Figure 8: Crack initiation and propagation length history in PMMA beams subjected to impact with different impact velocities

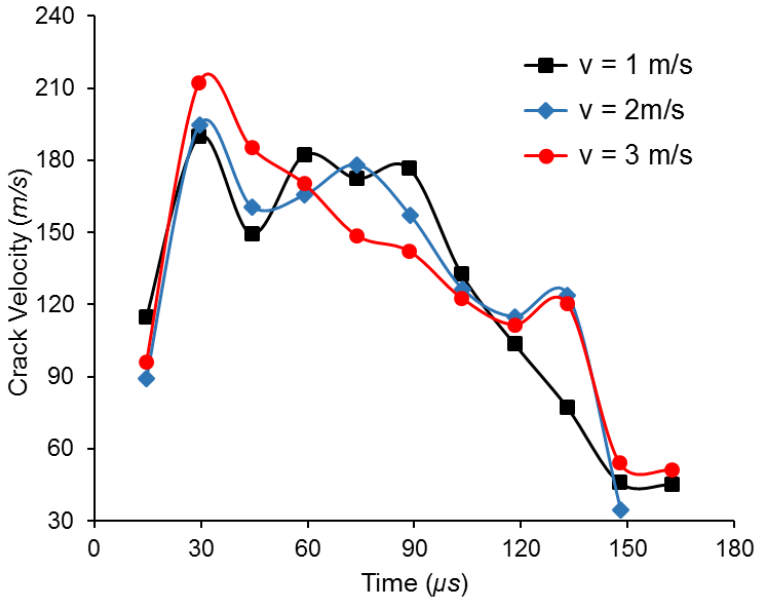

Figure 9: Crack speeds after crack initiation in PMMA beams subjected to impact with different impact velocities

The crack propagation speeds after crack initiation in PMMA beams subjected to impact with different impact velocities are shown inFig. 9, in which the time is set as 0 at the crack initiation point.The crack velocities in beams subjected to different impact loading have the similar trend. Crack velocities start from a relatively lowervalue round 100 m/s, then rise to the peak value round 200 m/s, and decrease till the fracture. The peak crack velocities for fracture in beams subjected to different impact are different. For fracture in the beam under theimpact of 3 m/s, the peak crack velocity is highest as 212 m/s. The peak crack velocities in thebeam under theimpact of 2 m/s and 1 m/s are lower as 195 m/s and 189 m/s respectively.

IV. Conclusion

The impact-induced dynamic fracture initiation and propagation in single-edge-notched PMMA beams have been analyzed in this paper. Crack initiates later after the contact of impact when it is subjected to smaller impact velocity. During the dynamic fracture process, crack velocities rise from a lower value, then reach the peak value, and then decrease till fracture. Peak velocity of the fracture in beam subjected to bigger impact loading is higher than that in the beam under smaller impact loading.

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Modeling of Stressed State Crankshaft of Boosted Diesels

By Nadezhda Marina & Ekaterina Ovchinnikova

National Research Nuclear University

Abstract- The high alternating dynamic loads on the crank mechanism set for diesels challenge improve operational reliability connecting rods and crankshafts, which cannot be solved without a large complex of scientific research. As the experience of JSC «Volzhsky diesel them. Mama's "study the stress state of the connecting rods in a factory bench tests are expensive, require additional time and cost deadlines constrain the development of serial production of diesel engines. Solve the problem can be analytically using numerical methods of strength of materials, theory of elasticity, finite element. However, this approach is real only if the disposal of researchers of modern computer technology and software, corresponding to the level of complexity of tasks.

Keywords: the high alternating dynamic loads on the crank mechanism; increase operational reliability; the polarization optical method.

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I. Introduction

The problem of increasing of operational reliability of crankshafts boosted diesel engines is especially important due to the impact of variables dynamic loads, causing metal fatigue cracks. One of the main means of solving of the research problems of crankshafts or their models with high gradients of stress to determine stress points and obtain a picture of the whole area of the structures are the following physical methods: brittle lacquer method, moiré fringe method and polarization-optical method.

II. Methods

A prospective way to study the stress-strain state of the structures of the engine is the modeling on planar and three-dimensional photo elastic models. The solution of the problems in terms of stresses and isostatic model of the connecting rod [1] is known, and it resulted in qualitative pictures and diagrams of isochors and quantitative distribution of stresses in fringe arrangement. In comparison with other methods this polarization-optical method eliminates the full-scale research designs that require bulky and expensive equipment for loading, register the stress pattern along the crankshaft continuously, which is its main advantage. The accuracy of the polarization-optical method increases in locations with high stress gradient and does not depend on the environment. In comparison with the non-contact physical methods such as a method of brittle lacquer and method of moiré fringes the polarization-optical method makes it possible to get results the directly with high accuracy and with little expenditure of funds.

Polariscope with diffuser is taken as an instrument for the study of stress-strain state of crankshafts with polarization-optical method [1]. It should be noted that such polariscopes were not used in our country, and significant research effort was applied to optical systems for the creation of parallel light beams. There is no information on the study of model of the crankshaft engine with polarization-optical method in the technical literature.

III. Main Part

At JSC «Volgo Diesel – Mamins» the reduced scale models of the crankshaft were made of optically active material based on epoxy resin EH-5 of hot curing. Manufacturing technology of material includes the development and forms making, blending of components, pouring the mixture into molds, polymerization, forms disassembling and annealing the workpiece.

Plasticizer (dibutyl phthalate) is added into preheated to 80°C epoxy, and then the polymerization accelerator (dimetilanalin) and at last hardener (methyltetrahydrophthalic anhydride) in an amount of up to 40% are introduced. After the addition of each component, the mixture is thoroughly stirred at a constant temperature of 80`C. The prepared mixture is poured into preheated to 50-60°C forms. Polymerization of the material takes place in an oven under the condition of a slow rise in temperature.

Polymerization condition:

- model holding at 80°C for 24 hours;
- temperature increasing up to 100°C at 50°C per hour;
- model holding at 1000°C for 24 hours;

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– temperature increasing up to 120°C at 50°C per hour
– holding at 120°C for 24 hours;
– gradual temperature decrease (for 2.50C per hour) to 60°C.

The produced model was annealed to relieve residual thermal stresses and stabilize the properties of the material at 130°C. Temperature increasing during the annealing occurs 10°C per hour while the reduction occurs 50°C per hour.

The main property of the elastic model of crankshafts used in the study of stress-polarization optical method is their optical sensitivity, which is an indicator of the stress ratio or the price of a strip of material [2]. High optical sensitivity of the used material gives the simplicity and accuracy of measurement. To determine the stress optical ratio flat calibration pattern in the form of a disk, which was tested for compression by diametrically applied forces (Figure 1) was produced.

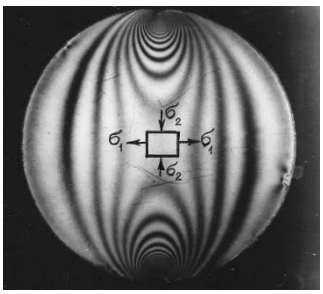

Figure1: Flat Calibration Sample

Simultaneously with the optical constant measurements longitudinal and transverse strains disk to determine the elastic modulus and Poisson's ratio for the formulas of the theory of elasticity

$$E = \frac{4(4-\pi)\cdot P}{\pi\left[4(D_2 - D_1)t_1 - \pi \cdot D(t_2 - t_1)\right]},$$

$$\mu = \frac{4-\pi}{4\frac{D_2 - D_1}{D_1}\cdot\frac{t_1}{t_2 - t_1} - \pi}$$

where P - force disk compression; D_1 and D_2 - length of horizontal diameter of the disc before and after loading; t_1 and t_2 - center thickness of the disc were carried out. In the given case $E = 34 \cdot 10^8 МПа$, $\mu = 0{,}37$.

To investigate the polarization-optical method models of the crankshaft were placed between the polarizer and analyzer, and their loading was carried out in the load frame via a hard disk with a bolt.

By modeling the loaded state of the crankshaft qualitative pictures and diagrams of quantitative isochors expressed in distribution of fringes arrangement of quasi-static stresses on the loaded circuit model (Figure 2) have been obtained.

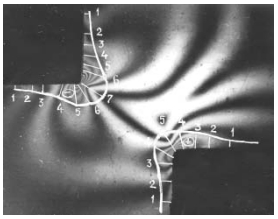

Figure 2: Diagram of Quasi-Static Stress Distribution in Fringes Arrangements on Crankshaft Model Outer Loop

IV. Conclusion

By modeling the stress state of the crankshaft by polarization optical method qualitative pictures of the isochors for different models of the tribe of the crankshaft and diagrams of the quantitative distribution of stresses in fringes arrangements. On the basis of fringe patterns processing theoretical stress concentration factors in the fillets of the crankshaft are defined.

Table 1: Theoretical Stress Concentration Factors in the Fillets of the Crankshaft Variants of Crankshaft Fillets

Options crankshaft fillets	The maximum order of the bands n_{max}	Nominal order strips n_{nom}	The theoretical stress concentration factor $k=n_{max}/n_{nom}$
1	6	2,5	2,4
2	5	3	1,7
3	10	4,5	2,2

Realized and studied according to the proposed method fillet crankshaft optimum profile for the engine 6ЧН21/21 provide reduced theoretical stress concentration factor from 2.4 to 1.7, i.e. 30%, as confirmed by studies on flat models of crankshafts. It allows optimizing and reducing the value of the maximum stress at a minimal structural changes and increase service life and operational reliability of crankshafts boosted diesels. Considerable optimization of the distribution of stresses in the fillets of crankshafts can be achieved by a set of structural measures to reduce both the total related to the form of knee-shaft, and the local stress concentrations, depending on the relative curvature and shape of the profile of the fillet.

When determining the causes of the accident of crankshafts according to the nature of the fracture it is necessary to find out its root cause that led to the stress concentration and the place where the sequential formation of a fatigue crack started. In this case the main problem is to retard cracking, to remove and disperse crack stress concentrators from the tops. In this connection the selection of process of a method of

surface plastic deformation by the artificial creation of the initial processing of the residual compressive stresses [2] on the elements of the crankshaft is required.

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The Influence of the Initial Technological Residual Stresses on the Bearing Capacity of Crankshafts Boosted Diesels When Plastic Deformation

By Nadezhda Marina
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Abstract- The exact manufacturing techniques of cranked shaft from stamped preparations at size provide indemnification of influence of the layer not strengthened without carbon from the differentiated water stream of processing, that, in turn, demand research of influence of initial technological residual pressure on the basic loading of the strengthened cranked shaft.

Keywords: the analysis of fatigue failures, revealing of concentrators of pressure, initial technological residual pressure, superficial hardening.

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I. Introduction

Fatigue strength of modern crankshafts of combined boosted diesel engines with alternating dynamic loading is provided mainly by the reduction of existing dynamic stresses by increasing the size of the cross sections, the neutralization of the stress concentration and the use of high-strength materials. The problem of increasing of the utilization ratio of the material in the manufacturing of crankshafts by applying blanks with high accuracy of production is of great importance. Under these conditions, other ways of increasing fatigue resistance, which are connected with the progressive and highly effective methods of strengthening only in those parts of a construction where fatigue failure is possible is of much greater importance.

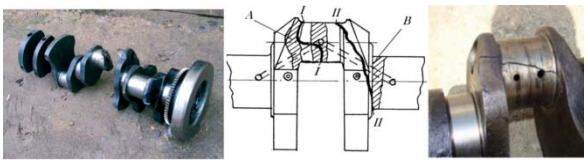

Figure 1: Most Common Crankshaft Damages in Stress Concentration Areas: A) on crank pin; B) on the cheek

Analysis of fatigue failures of crankshafts in the area of the oil hole in the crank pin and on the cheek from the action of the bending moment in the plane of the knee shows that the nucleation of fatigue cracks in the fillet radius of the transition of the crank pin into the cheek and on the oblique section of the connecting space pairing cheeks with crank pin is observed. A similar pattern of fracture developing indicates a high level of working stresses from the bending loads and their presence in a high concentration. To reduce the stress concentration and increase the carrying capacity of the crankshaft fillet zone it would be advantageous the use of surface plastic deformation - hardening of the transitional radius of the indigenous and crankpins of the crankshaft into the cheek with hydro crusher treatment (HCT), which allows to control the properties of the surface layer formation of an initial processing of residual stresses (IPRS) compression. Under the alternating loads the arrangement of the distribution of last in depth of the surface layer of the crankshaft elements is not the main thing in comparison with the magnitude and sign of the stresses on the surface [1]. Therefore, the properties of the hardened differentiated HCT of crankshaft are influenced by IPRS axial compression directed along the cheeks and counterweight, as axial compression coincides with the developing dynamic working stresses. In addition, low-waste technology in the manufacturing of crankshafts by applying blanks with high accuracy of production provides for compensation for softening the impact of the decarburized layer of differentiated HCT, which, in turn, requires a study of the effect on the carrying capacity IPRS of hardened crankshafts. In the technical literature there are no publications on generalizing the problem of increasing the fatigue resistance of crankshafts with differentiated HCT and this fact retards the development of research and the practical use of the results in this field.

II. Results and Discussion

For a comprehensive evaluation of changes in physical and mechanical condition of the surface layer in the zone of stress concentration at the fillet radius of the zone of the crank pin of crankshaft with differentiated HCT testing plate are used at Volgo Diesel - MAMINS as samples witnesses made of hardenable material items, while believing that the static deflection is a measure of the intensity and stability of the process with differentiated HCT of a hardenable structure. However,

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vibro-impact loading of the crankshaft and the testing plates - witnesses with differentiated HCT is different from static one that requires to take into account the comprehensive criterion - the coefficient of dynamic load CD. The research conducted on the flat sample witness of rectangular cross section have determined that the HCT parts K_D is= 1.2 [2]. Since IPRS compression distort the shape of fillet radius transition new approach for assessing IPRS under vibro-impact dynamic loading. Approximate analytical assessment of this form of distortion can be done by considering the state of stress separate strips fillet area of the sample-witness in the form of radius element the width of which is b (φ = 45 °) going perpendicular to the axis of the fillet area and determining the change of sag deflection Y_0 under the influence of the induced residual stresses (Fig. 2).

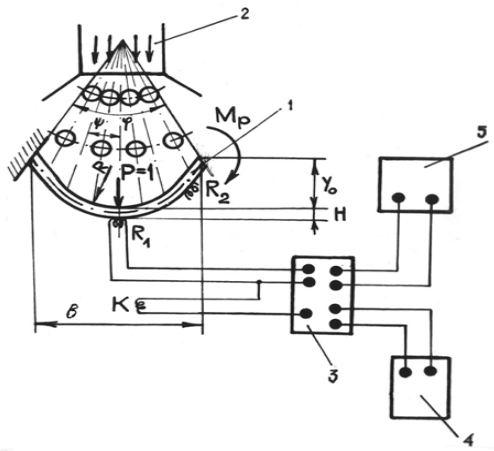

Figure 2: Research diagram of the initial processing of the residual stresses in the sample-witness (fillet area) of crankpin and radical pin of crankshaft with differentiated HCT.

Moment M_R formed as a result differentiated HC treatment deforms the element in question in the direction of reducing the sag deflection. Since the ratio of the sample thickness H to the radius R is small, the internal force factors Q and N are not taken into account, and based on the known dependence Mora for crooked timber for linear static change Δip deflection has the form

$$\Delta_{ip}=\int_0^{\varphi/2}\frac{M_p\bar{M}_i R d\varphi}{EI}+\int_{\varphi/2}^{\varphi}\frac{M_p\bar{M}_i R d\varphi}{EI} \qquad (1)$$

where $\bar{M}_i = PR\sin\psi = R\sin\psi$ the bending moment from a unit force P = 1 applied in determining the deflection.

Whereas $\int_0^{\varphi/2}\frac{M_p\bar{M}_i R d\varphi}{EI}=0$ after the transformation $\Delta_{ip}=\frac{0.2M_P^0 R^2}{EJ}$, and the moment $M_P = bh\sigma_x^0\frac{H}{2}$, where h - depth of plastically deformed layer, calculated according to well - known technique [1].

Thus, $$\Delta_{iP}=\frac{0{,}1bHR^2\sigma_x^0 h}{EJ} \qquad (2)$$

where σ_x^0 - initial residual stresses in the- radius zone of the sample –witness at technological static loading.

The amplitude of the dynamic plate deflection with differentiated HCT is $\Delta_{iPД}= К_Д\Delta_{iP}$. The dynamics of loading from HCT IPRS in radius area of the sample-witness

$$\Delta_{iP}=\frac{0{,}1bHR^2\sigma_x^0 h}{EJ}, \qquad (3)$$

For the experimental evaluation σ_{xx}^0 in a separate strip of fillet zone after differentiated HCT at Volgo Diesel - MAMINS special research a block diagram of which contains cantilevered thin surface element 2 radiuses R (Figure 3), which is a one-sided cavity treated with vibro-impact from the nozzle 1 in the chamber installation GDEU-5 was conducted. Working R_1 and R_2 and the compensating K strain resistor included in the amplifier 3 strain resistor station 8ANCH TM were glued on the opposite side of the unreinforced surface element R_2 was installed on a flat plot of the element in the immediate vicinity of R_1, glued to the curved area. This scheme allowed installation of strain gages to investigate the state of stress of both flat and rounded fillet area, thus eliminating errors associated with changes in the state of stress at the ends of the samples (edge effect). The converted signal of dynamic deformation of the surface element on the loop oscillograph recorded 4 brands H-115. The circuit is powered from the power P-131. Before carrying out research working resistors were statically calibrated on the special device with the task sag deflection micrometer and its monitoring by indicator. Oscillograms of dynamic stresses in the zone of their concentration in the HCT and on the flat part of the surface of the element were received/ (Figure 3a, b).

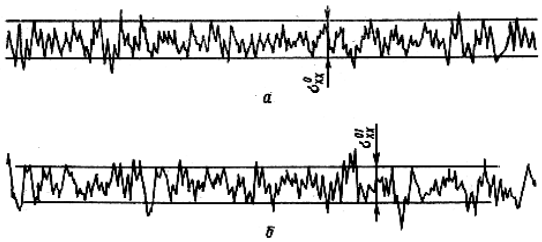

Figure 3: Oscillograms of Dynamic Stresses in Zone of Their Concentration in Sample-Witness with HCT: a) from gage R_1; b) from gage R_2

Initial technological residual stresses on the flat part of the sample at its removal from hydro crusher setting were determined according to the technique for a flat rectangular element

$$\sigma_{xx}^{01}=\frac{8E}{l^2}\left(\frac{H}{2}-h\right)y_c,$$

where y_c - static deflection amplitude of the cantilever plate.

Taking into account the nature of the vibro-impact loading sample witness with differentiated HCT, this expression is replaced by the amplitude of the amplitude y_C y_0 known relation $y_0 = K_D \cdot y_c$.

III. Conclusion

According to the latest formulas for cantilevered plates in a cell radius fillet area of the crank pin and crank engine crankshaft 6CHN21/21 define IPRS in a hollow on a flat plot and concentration factor IPRS at l = 0.04M, H = 2 · 10-4M, h = 2,82 · 10^{-4}M, σ_{xx}^{0} = -110MPa, σ_{xx}^{01} = -75MPa, α_σ = 1,5.

The foregoing leads to the following conclusions. During the study found that IPRS compression in rounding conjugation of the main and connecting rod journals and the crank web at differentiated HCT create the same stress concentration as well as operating stresses by the external loading of the crankshaft. The study of the crankshaft optimal profiles using plain models of the polarization-optical method [3] proves the foregoing: α_σ=1.7. This circumstance must be taken into account when assessing the reserves of the crankshaft fatigue strength. Using the differentiated HCT the adverse development of effective stress concentrators can be neutralized and the effect achieved can be greater than structural changes in the shape of parts, for example by means of the stress deconcentrator. It should be noted here that the effectiveness of stress concentration reducing by differentiated HCT is 40% in comparison with 19% effect from the deconcentrator.

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Production Planning and Control for the Comparative Advantage of Basic Metal Industry

By Alie Wube Dametew & Daniel Kitaw
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Abstract- This study is to assessed and investigate the challenges, trends and problems of production planning and controls on basic metal industries comparative advantages. Since the study is conducted with field observation, questioner ,company reports used as primary data and literature review of research articles, books, manuals, magazines, and electronic-sources which used as secondary data. A case study also conducted at the selected two basic metal industries. However, the collected data were analysis using descriptive analysis, SPCT(fishbone diagram).

Keywords: production planning and control, comparative advantage, basic metal industry, implementation, challenges.

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Keywords: production planning and control, comparative advantage, basic metal industry, implementation, challenges.

I. Introduction and Back Ground of The Study

Manufacturing facilities are complex, dynamic, stochastic systems. From the beginning of organized manufacturing, workers, supervisors, engineers, and managers have developed many clever and practical methods for controlling production activities. As a result numerous manufacturing industries have recognizing the importance of manufacturing strategy in their businesses performance and efficiency. Although, manufacturing industries apply and use those strategies in order to meet customer expectation and reduce production difficulties. Since in complex manufacturing environment, a comprehensive production planning and controlling process is adopted in order to ensure the best utilization of resources, improve production capacity and maximize a firms profitability. However these system provides for in manufacturing of basic metal industries production system is very important to make the sector more competitive due to the nature of the product. In this range production planning and control (PPC) systems are crucial for Basic metal industries(BMIs) to meet the increasingly high customer demands and expectations in the present, highly competitive, manufacturing climate. Because the approach involves system and resource planning, capacity and resource allocation, setting up and control framework. In addition production control, planning and scheduling may be defined as the technique of foreseeing every step in a long series of separate operations, each step to be taken and control at the right time and in the right place and each operation is to be performed in maximum efficiency. This ensures entrepreneurs to work out the quantity of material, manpower, machine and money required for pre-determined level of output in a given period of time. Thus, it is necessary to explore the effect of production planning and control on Basic metal and engineering industries(BMIE) performance and competitiveness. As a result this study is intended investigate and assessed the practices, the impact of production planning and control on Ethiopian Basic metal industries and Way forward for improving the firm performance and global competitiveness were done.

a) Statement of the problems

The manufacturing sector in Ethiopia contributes significantly to the development of the country. In spite of its contributions, it is plague by the following constraint. proper production planning ,Control and scheduling cannot be properly realize in the industries. As a results poor decision -making, problems procurement, production, in transportation and distribution, and in information processing and communication are seen. in addition cost of imported raw materials: Power fluctuations, Labour Intensive production, are the challenges that are seen in Ethiopian basic metal industries. Also inconsistent flow of production enquiry sheet preparation and evaluation, Raw material ordering, purchasing and supply system doesn't seem to follow any scientific inventory control system. Due to this Ethiopia basic metal industry are infant for Growth transformation program(GTP)economic

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contribution and poor competitive advantages. Since to Tackle the above problems this research was designed.

b) General Objectives

The main objective of this study is to investigate the effects of production planning and control on basic metal industries, so as to secure the comparative advantages by directing improvement strategies.

c) Research Methodology

The study is conduct through field observation, literature review of research articles , books, magazines, manuals, company report and electronic-sources which are discuss related to basic metal manufacturing industries growth, opportunities, economic contribution, challenges, strengths and performances in relation to production planning and controlling systems. The literature review focus on competitiveness, production planning and control function, principles, models, components such as Material Requirement Planning (MRP), Capacity Planning (CP), scheduling),Master Production Schedule (MPS) and Resource Planning are considered and assess in detail. The investigation consider attempts to explore production planning and control issue on basic metal industry trends, performance, competitiveness strategy, planning challenges, production planning and controlling effort is assessed. Followed by model development based on the literature survey and case study analysis is done. Finally the conclusion and recommendation of the study is done. Since for analysis of the problems, the researcher mainly uses SPCS tools like Cause and effect (Fish bone diagram), and descriptive analyses are used.

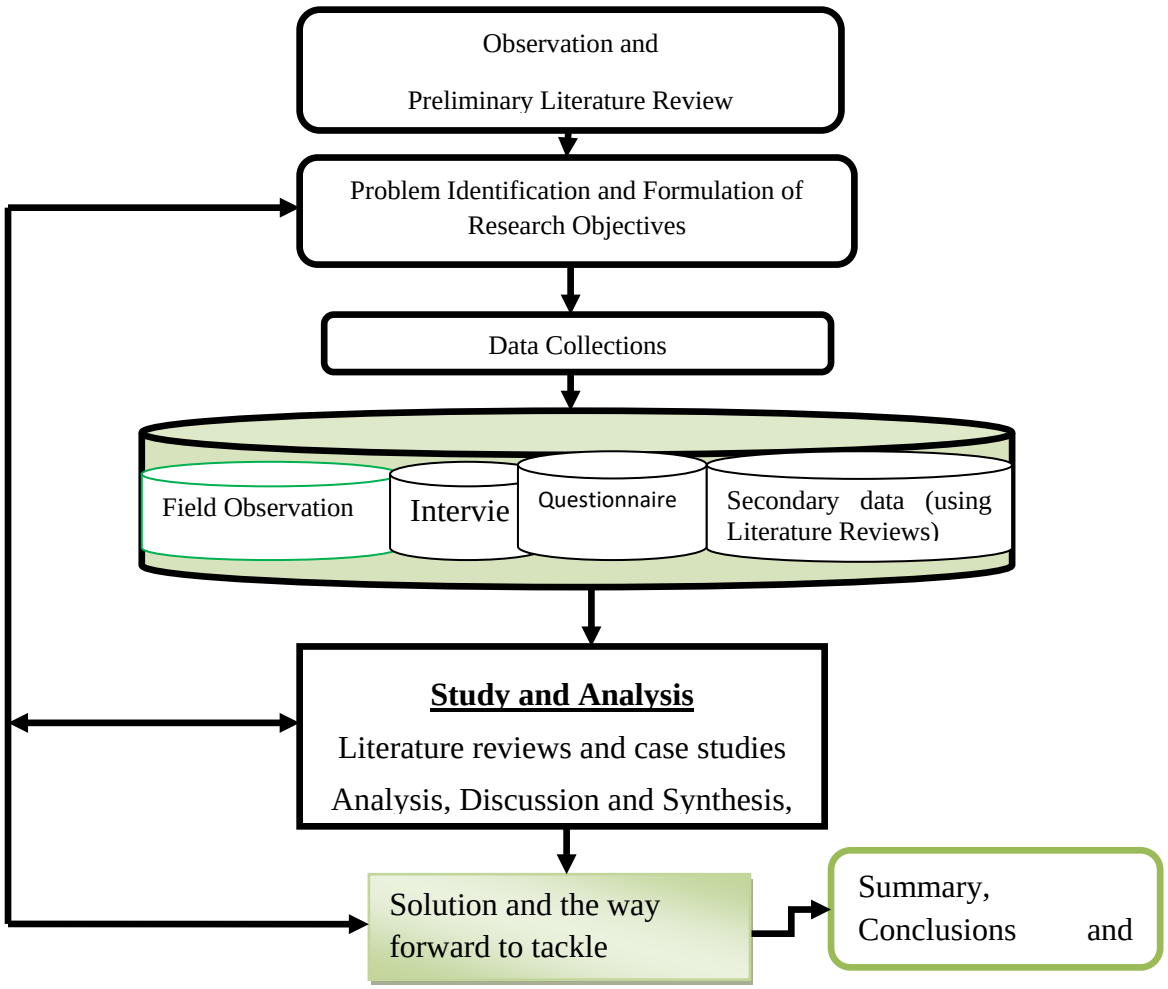


Figure 1: Research Methodology Frame work

II. Literature Reviews

a) Introduction

In this section from the previous research work a total of 124 articles were found out that published articles in the PPC area. Since, from this 124 articles in this section goes through 27 selected articles which are related one or more PPC classes presented . It makes the base for the discussion which comes on the next section. First we review the definition, concept, theory of production planning and control role in manufacturing industries. Then we expressed the components, principles, functions and Strategies used in production planning and controls. In the next step we review the

models of production planning and Control have been developed by different researchers and production planning and control as a revenue of competitiveness are assessed. After that the gaps and miss points in the previous study related to production planning and controlling are identified. The globalization of the economy and the liberalization of the trade markets have formulated new conditions in the market place which are characterized by instability and intensive competition in the business environment. Competition is continuously increasing with respect to price, quality and selection, service and promptness of delivery. International cooperation, elimination of barriers technological innovations cause competition to make stronger. In terms of manufacturing emphasis is placed on reducing cost while improving quality. Although competitive priorities defines the set of manufacturing objectives and represents the link to market requirements and meet customer needs, which have the dimensions commonly used are; cost, quality, flexibility, and delivery [5].

b) Production Planning and Control

Production: that transformation of raw materials to finished goods.

Planning: Planning is the process of selecting and sequencing activities such that they achieve one or more goals and satisfy a set of domain constraints. IT looks ahead, anticipates possible difficulties and decides in advance as to how the production, best, be carried out.

Control: phase makes sure that the programmed production is constantly maintained.

System: is a whose function is to convert a set of inputs into a set of desired outputs.

c) Production scheduling

Scheduling deals with the efficient allocation of tasks over resources. The general scheduling problem is, given a number of tasks and a number of resources, set the dates when each task should be accomplished on each resource. Since, production scheduling is a decision-making process that is used in manufacturing and service industries to achieve efficiency and minimize production cost. Since production schedule framework should be designed to meet company goals filling customer requirements with minimum total cost [10].

d) Production Control

Production control (PC) is the function of management which plans, directs and controls the material supply and processing activities in an enterprise [8]. Since PC concerned with, determining whether the necessary resources to implement the production plan have been provided. If not ,it attempts to take corrective action to address the deficiencies (shortages).Also Shop floor control, Inventory control are the main activities of production control.

Production planning: is the planning of production and manufacturing processes in a company or industry. Planning is also the primary managerial function for enterprises, which is the direction and instruction to coordinate and cooperate the enterprise's overall operation [6]. While, this is one of the most important activities in manufacturing enterprises. Since production planning, utilizes the resource allocation of activities of employees, materials and production capacity, in order to serve the customers. However production planning and control (PPC) plays a fundamental role in any manufacturing unities. This provides making routine for proper plant layout, raw materials requirement, utilizing resources, and maintenance of machineries are done. This results in a positive way by the improvement of productivity, quality, customer satisfaction, profit and global competitiveness. In the meantime, PPC concerned with implementing the plans, i.e. the detailed scheduling of jobs, assigning of workloads to machines (and people), and the actual flow of work through the system [7]. Also coordinate with different departments: such as production, marketing, logistics, warehouse and other departments depending upon the nature of organization. The other point is there are different types of production methods are found in a manufacturing firms, such as single item manufacturing, batch production, mass production, continuous production etc. have their own type of production planning. Production planning can be combined with production control into production planning and control, or it can be combined and or integrated into enterprise resource planning. Since currently, the framework that is most commonly applied to the deconstruction of planning activities is the use of three hierarchical levels that range from strategic to operational planning are strategic planning ,tactical planning and operational planning focuses. Since typically, these activities include the detailed production scheduling, inventory control, and lot sizing. Since mainly production planning concerned with deciding which products to make, how many of each, and when they should be completed, Scheduling the delivery and/or production of the parts and products, Planning the man power and equipment resources needed to accomplish the production plan and major activities like MRP,MPS(MPP),CP,APP are emphasis by production planning.

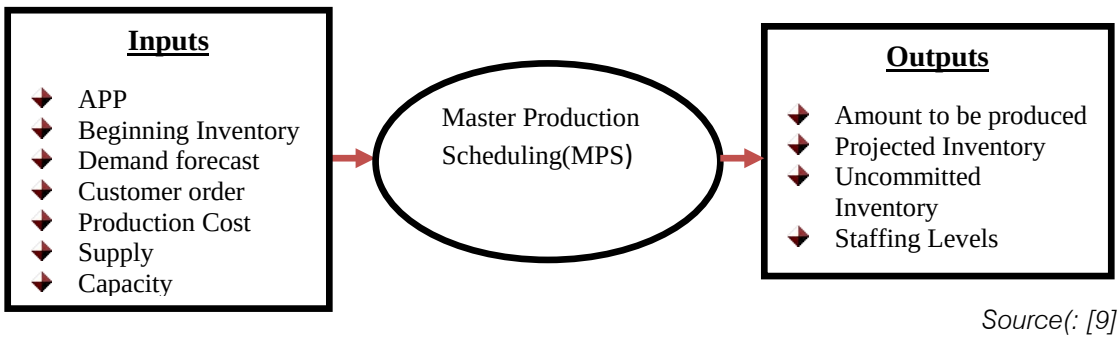
i. *Aggregate production planning*

Aggregate production planning (APP) is the process of determining output levels of product groups over the coming six to eighteen months on a weekly or monthly basis; the plan identifies the overall level of outputs in support of the business plan. APP is a

medium term capacity planning that determines minimum cost of workforce and production plans to meet customer demands. Main inputs of aggregate production planning are resources, demand forecast and employment policies. Since, APP aim is to determine the production quantity and inventory level in an aggregate term. However, The company starts its plan by stating its business plan. Business plan is a statement of an organization's overall level of business activity for the coming six to eighteen months, usually expressed in terms of monetary values of sales for its various product groups.

ii. *Master Production Schedule*

The Master production planning/ master production schedule (MPS) sets the quantity of each end item to be completed in each week of a short-range planning horizon. The MPS sets its production schedules based on forecast, orders and lot size of the customer order [9]. It uses information from both forecasts and orders on hand, and it is the major control (driver) of all production activities. In fact, the MPS begins as a trial schedule. If these schedules are feasible, the schedule becomes input for the MRP system. MRP sees this schedule as given: the system cannot check if a schedule is correct or incorrect, for example if a schedule goes beyond production capacity or not. The MPS can be updated or modified anytime a production-manager wants. As a result of these changes the MRP-input changes, as does the production output. Thus the MPS is in reality the mother of all schedules, and it is a plan for future production of end items, set by market forecasts, customer orders, inventory levels, and other information necessary to make correct schedules. Hence, an effective master production schedule provides the basis for , Making customer delivery promises , exploit the capacity of the plant effectively, Attaining the strategic objectives of the firm as reflected in the production plan and Resolving tradeoffs between manufacturing and marketing.

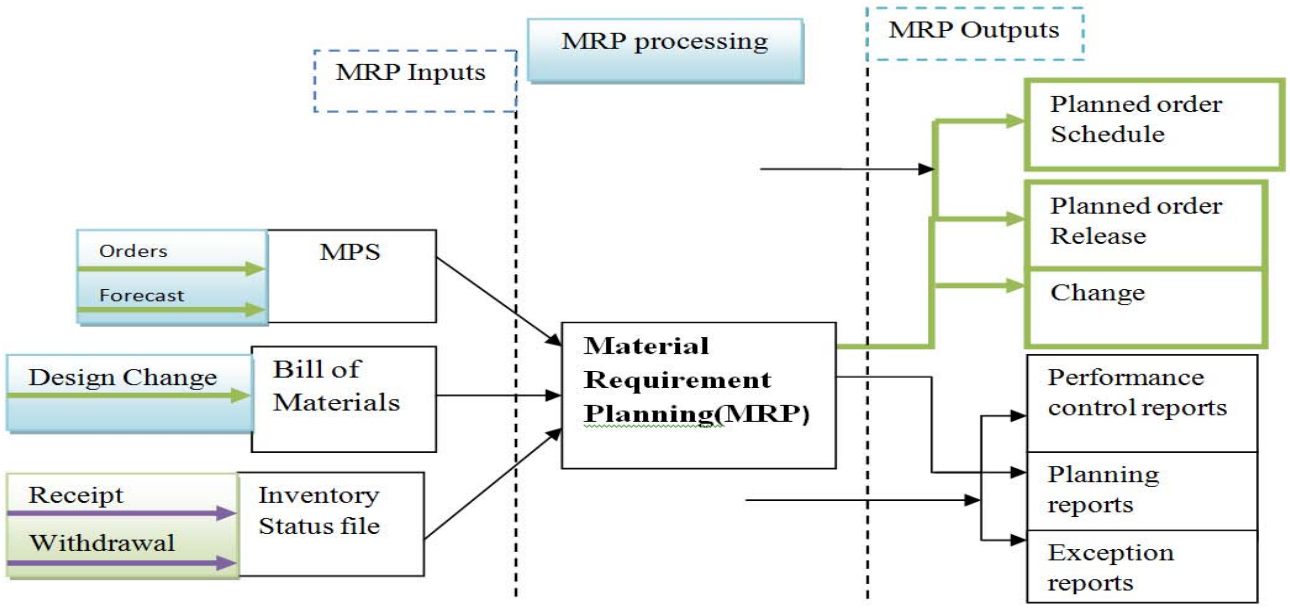


Source(: [9]

Figure 2: Inputs and outputs of MPS

iii. *Material Requirements Planning*

After preparing the master production schedule, we need to think of availing all the necessary materials to manufacture the planned items. Materials requirements planning (MRP) is a means for determining the number of parts, components, and materials needed to produce a product. MRP provides time scheduling information specifying when each of the materials, parts, and components should be ordered or produced. In a comprehensive definition MRP is a time phased priority-planning technique that calculates material requirements and schedules supply to meet demand across all products and parts in one or more plants. this is a material control system that attempts to keep adequate inventory levels to assure that required materials are available when needed. Although Materials Requirement Planning (MRP) is based on the philosophy that each raw material, part and assembly needed in production should arrive simultaneously at the right time to produce the end items in Master Production Schedule (MPS). So inventory levels could be reduced, production capacity could increase as well as the profits. However, an MRP package takes into consideration: Customer Orders, Forecasts, Shop Orders, Parent part requirements, Inventory Management, Bills of Materials (BOMs), Purchasing, Receiving, Stockroom Control, Accounting and Invoicing.



Source: [10]

Figure 3: Inputs and Outputs of MRP

iv. *Capacity planning*

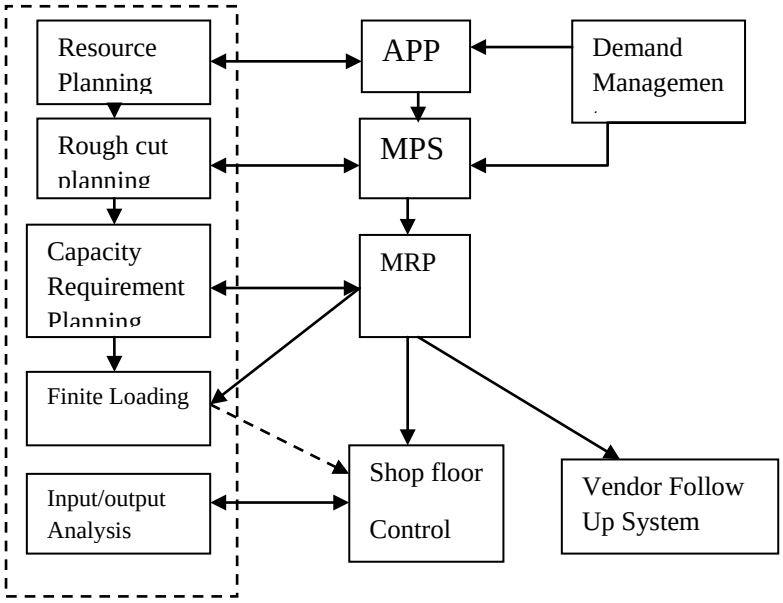
Capacity planning-concerned with determining labor and equipment resources required to meet the current master schedule as well as long-term future production needs of the firm. Production capacity is the maximum limit or ceiling on the load (product) that an operating unit can handle. It is the rate at which outputs are achieved from a process. It can be expressed as number of units that can be produced per unit of time, maximum size of a work piece that a machine can handle, or maximum weight of a work piece that can safely be loaded on a machine. Although capacity planning determines what labor, time and equipment resources are required to meet the current MPS as well as long term production needs of the manufacturing industries [9].

Since, output level of an item is dependent on the production capacity of operating units (plants, departments, machines or workers) used to produce the item. For manufacturing industries , production capacity is the maximum limit or ceiling on the load (product) that an operating unit can handle. This is the rate at which outputs are achieved from a process. According to [12] the capacity measures used in auto and steel companies are in terms of outputs. Inputs are used as capacity measures for job order companies. As a result, an estimate of capacity may be measured in terms of either input or outputs.

$$\text{Capacity Efficiency} = \frac{Actual\ Capacity}{Design\ Capacity}$$

Source: [12]

In addition for performance estimation purpose capacities are grouped in to two. They are design capacity and effective capacity. Design capacity is the amount that a firm would like to produce under normal circumstances and for which the system was designed. Effective capacity is defined as the maximum possible output given a product mix, scheduling difficulties, technology, machine maintenance, quality factors, and so on.



Source: [10]

Figure 4: Capacity Planning in PPC Systems

In addition different production and Scheduling strategies are used by many companies around the world. Some of these most commonly used strategies are Chase strategy , Make-to-Stock, Assemble to Order and Make to Order [9] [11]. These strategies are allows manufacturers to produce goods in long production runs, taking advantage of production efficiencies, the company continuously produces goods equal to the average demand for the goods, produce goods after receiving an order from the customer and assembled products from a stock selection of ingredients. This improves the competitiveness of the firms and enhance comparative advantage.

e) Advancement of Production planning and controls

In manufacturing industry the amount of information available to manufacturers and their suppliers for decision-making has become an important factor in improving manufacturing productivity. Manufacturing firms have always sought ways to improve their competitiveness. During the first half of the twentieth century, internal manufacturing efficiency on the shop floor was largely sufficient for successful operations. Though, with growing struggle, companies have been forced to find new ways to improve their operations and to look beyond the walls of the factory. Currently, manufacturing firms need to be competitive in different aspects, such as quality, delivery, cost efficiency, and flexibility, and must therefore plan and control their operations accordingly [20].

Since for achieving sustainable and competitive production environment planning and control task has become more critical for improving complex systems ; lead times are shorter, improve product life cycles, reduce bottlenecks more effective and efficiently.

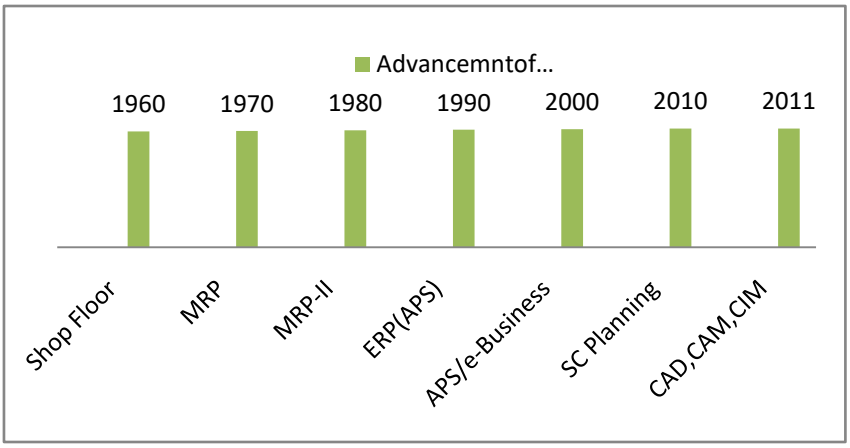


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Figure 5: The growth of Production planning and control Systems

The above figure illustrates how the important point of production planning and control has shifted over the last 50 years. The perspective has successively evolved from lower (shop floor) to higher planning and control stages. the figure clearly show that the developments in information and communication technologies (ICT) have assist the gradual improvement of computer based systems for PPC. Thus, current advanced PPC systems significantly utilize advanced computerized systems and programs. This is highly interlinked with the fact that manufacturing has been simplified with Computer Aided Manufacturing (CIM) systems [9]. In addition to this Computer-aided design (CAD) is provides any design activity that involves the effective use of a computer to create, modify, analyze, or document an engineering design.CAM/CIM mainly concerns for Flexible manufacturing systems can react quickly to product and design changes. A FMS includes a number of workstations, an automated material handling system, and system supervisory computer control. Since due to the global competition and fast change customer requirements, implementing CAM/ CIM systems in manufacturing industries is beneficial. Because CIM program could provide products with better quality, lower costs, better support, and in a short lead-time. But Implementing CIM requires organizational and technical understanding and strategic approach. As a result any organization should know the way of implanting CIM approach for program improvement and global competitiveness. Thus Ethiopian Basic metal industries should considered Computer-integrated manufacturing (CIM) for blend recent developments in manufacturing with information technology to achieve competitive advantage.

f) Analysis and Discussion of Literature review

In the previous sections a literature review was presented on variety of perspectives towards production planning and controlling concepts, theory , function, the practice, implementation strategies, the models that developed and practiced for manufacturing industries , so as to improve manufacturing firm performances are assessed. However, a general so far important issue is that many of the studied articles have hardly built on previous works. Most researcher seem to open a new window and develop their argument, models, factors, parameters, the potentials for considering the preview related works. While, the previous research [21],[22],[23], [24], [18],[25][17] , we found that, the majority of papers is done using different types of models but they analysis and studied some aspects of production planning and control.

Also, each of the papers has not any certain rationale for choosing the models they used. Although, the challenge for today's business companies is not only how to adapt to changing business environment but also how to draw competitive advantage from the way in which they choose to do so. Seeing that, a root to achieve competitive advantages, the companies have happening to seek to optimize production systems. Given that, traditional production planning, scheduling and control mechanisms were found insufficiently flexible to respond to this new paradigm. In the fact that, in the current competitive environment, effective and efficient production planning and control has become a necessity for endurance in the market place since, using PPC in the industry can have an advantage for customers, producers, employees and stake-holders, and also for the nation. Better planning leads to increased productivity in the firm, efficient deliveries of the products at proper time, more products available to the consumers at cheaper price, flexible manufacturing process and better quality.

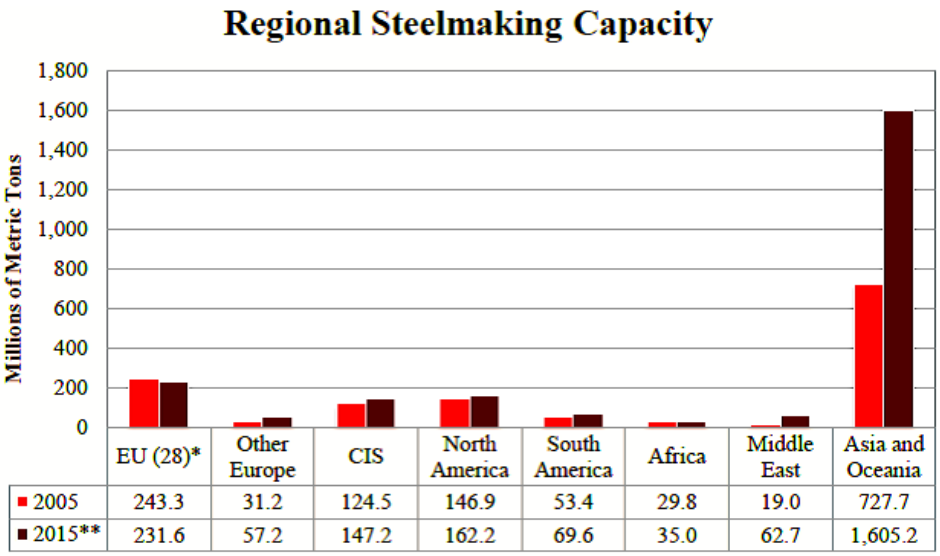
Another point we found that, inspiration the growing of production planning and control systems for manufacturing industries improvements. In this respective the systems was evolved from lower (shop floor) to higher planning and control ICT support stages [20]. However, this development is in a much

earlier stage and by far not as widespread among the manufacturing systems as the quality and the customer satisfaction production initiative. However, the potential efficacy of improvements in manufacturing firms are evident. As main concerns of production planning and control systems are to balance from different aspects of the firms from supply of resources to demand, from the market, to allocate resources in the most effective way, from production to distribution , customer satisfaction to sustainability of the business and production to make recycling part is most promising in being effective and efficient in resource utilization and improve performance and competitiveness of manufacturing industries. On the other hand the preliminary miss point is that ,in various production planning and scheduling models applied to discrete parts manufacturing industries and process industries. It is seen that models have been developed in single stage and multi-stage production environment. Most of the models in multi-stage production environment have focused on fabrication and assembly types of product structures. The production environment with recycling process and its associated complexities has not been addressed in the literature [23]. But in manufacturing process recycling is an important issue in bringing down production costs.

The review also indicates that, the existing models on production planning and control do not address the complexities of the production environment to improve firm competitiveness [24]. Since it needs to develop an integrated models to address production planning and controlling tasks, production planning and controlling decisions, inconsistency often occurs in capacity requirements of production planning decisions and controlling decisions. As well we discussed that in the above literature while the issue of developing country firm competitiveness relayed to production planning and controlling systems is not address. In addition to these most of the previous research work were done, using secondary day but to tackle the exact problems and improve the practical environment the study should supported by case studies. As a result, in this study we considered a case studies for improvement of manufacturing firms.

III. World Region Crude Steelmaking Capacity

Between 2005 and 2015, each region except the European Union had increases in its total amount of steelmaking capacity. Asia and Oceania saw the largest increase, adding 877.5 million metric tons of capacity over the period, for a total capacity of 1.6 billion metric tons in 2015. Notably, Asia and Oceania accounted for 89 percent of the 987.8 million metric tons of global steelmaking capacity added since 2005. The Middle East ranked second with an increase of 43.7 million metric tons, followed by Other Europe which added 26.1 million metric tons and CIS which added 22.8 million metric tons. Capacity in the European Union decreased by 11.7 million metric tons between 2005 and 2015. In 2015, Asia and Oceania accounted for 67.9 percent of global steelmaking capacity, an increase of 15 percentage points from 52.9 percent in 2005. The European Union ranked a distant second with 232 million metric tons of capacity, or 9.8 percent of global capacity. The chart below indicates annual growth rates of both global steelmaking capacity and regional steelmaking capacity.



	EU (28)*	Other Europe	CIS	North America	South America	Africa	Middle East	Asia and Oceania
2005	243.3	31.2	124.5	146.9	53.4	29.8	19.0	727.7
2015**	231.6	57.2	147.2	162.2	69.6	35.0	62.7	1,605.2

Source: [26], [27]

Figure 6: Regional Steel Making capacity

According to WSA reports, global steel consumption has been highly dominated by Chinese, Asia and European Union countries. However, taking closer look into African situation along with the Middle East, consumption, it has been growing slowly.

Although, consumption of steel products follows the trend of economic activity in individual countries. Since the volume of steel consumed has been the indicator for measuring development and economic growth of the countries. Whether it is construction or industrial goods, steel is the basic raw material. Since, Steel consumption increases when economies are growing, as governments invest in infrastructure, electric power, transport, and as new factories and houses are built. After being in the focus in the developed world for more than a century, attention has now shifted to the developing regions. Even though , the industrial growth of African including Ethiopia basic metal industry is low. As a result currently the global competitiveness of Ethiopian Basic metal industry is poor.

a) Ethiopian Basic Metal Industries Competitiveness and PPC

The government of Ethiopia the Growth and Transformation Plan has given high priority to the metal and engineering industry sector. The steel industry is made up of basic metal manufacturing companies and the engineering sector. The Ethiopian basic metal industry produces two categories of products: long and flat products. Long products include reinforcement bars and tubular sections and wires, while flat products comprise LTZ profiles and various sheets: such as steel (lamera), corrugated, and EGA. The engineering sector consists of manufacturers of doors and windows, tankers, vehicle bodies, truck trailers, spare parts, and machinery like concrete mixers and vibrators [4]. Since ,an objective and target has been set to enhance the productivity and competitiveness of basic metal sector. It is planned to increase the annual per capital consumption of the country from 12Kg to 34.72kg and the capacity utilization of the existing industries to 95%. Also, substituting of imported metal products and supporting other manufacturing industries are some of the main targets of basic metal and engineering industry sector as indicated in the growth and transformation plan. Even though [29] report shows that, basic metal industry has under-performance both in terms of production and revenue generation. A according to report , the performance of the sector are decline compared to expected targets. Out of the total planned production of 343,105tns, only 52% was achieved by 60 industries in various areas.

Table 1: Production performance of Basic metal industries

NO	Type of products	Design Capacity	Measuring	2009	2010	2011	2012	2013	2014
1	Reinforcement bars	1,191,860.00	Plan (Ton)					552,492.27	732,299.24
			Actual (Ton)	91,124.00	138,846.00	47,956.00	228,588.43	386,269.70	454,285.60
2	hollow sections & steel profiles	456,071.21	Plan (Ton)					82,177.15	161,972.33
			Actual (Ton)	22896.5	48,592	49657	66151.58	48,641.81	78,849.53
3	Roofing sheet	460,029.00	Plan (Ton)					209,915.81	279,328.72
			Actual (Ton)	83995.66	129455.11	162,214.05	121,752.00	144,018.71	161,446.48
4	wire & nails	85,200.00	Plan (Ton)					60,131.53	72,753.65
			Actual (Ton)	18413.29	24539.035	30,136	38,531.03	34,117.71	30,646.77
5	Aluminum profiles	8,100.00	Plan (Ton)					1,252.68	798
			Actual (Ton)	120	300	445	334.79	468.42	546.57

From the saw that even if the performance of basic metal industries had some improvements from year to year but the planned and the actual production capacity have great differences/variations.This indicates that the performance of basic metal industries going to back-warded. As a result the global competition of the sector still infant and null. In addition to this, the following figure shows the iron and steel manufacturing process consists of four distinctive stages, spanning multiple industries: exploration and extraction, mining beneficiation, metallurgical beneficiation and shaping and conversion/fabrication and manufacturing/end user industries.

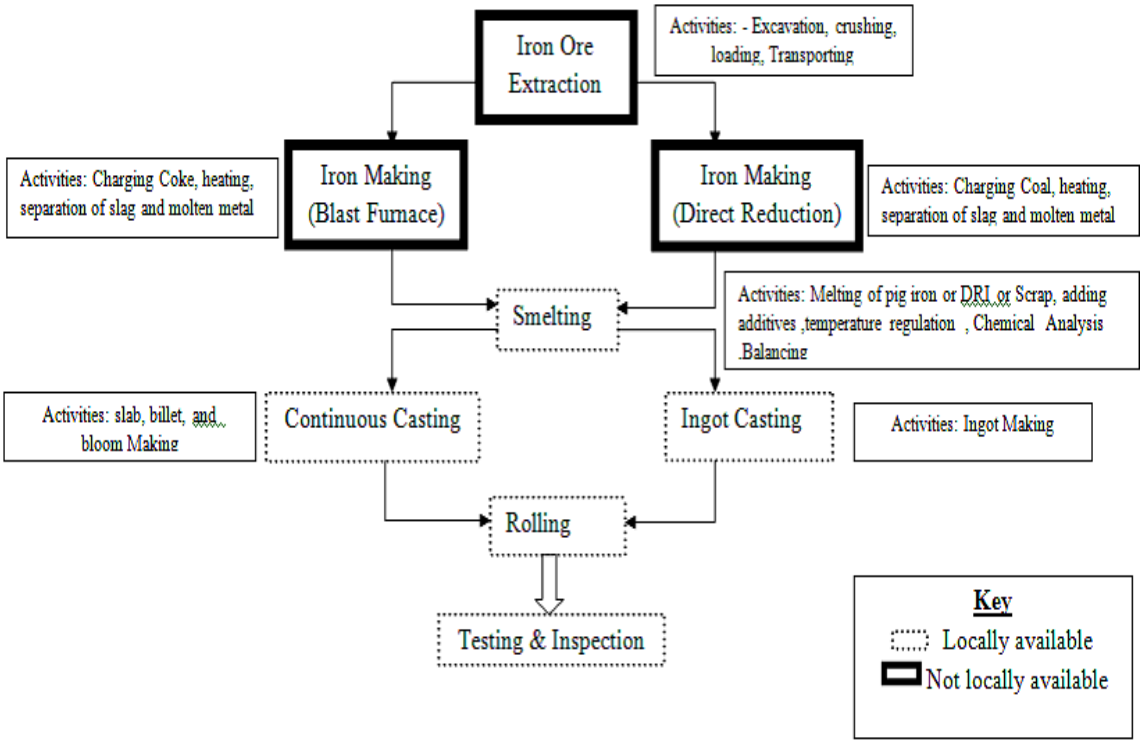


Figure 7: Production flow of steel from ore and Scrap

Eeven though iron ore is believed to exist in Ethiopia, it is not mined in the country. Bars and billets are produced from iron ore, coiled wire rods, from which nails are made, and coiled sheets are imported as raw materials. The above figure also clearly shows that the Ethiopian steel industry heavily depends on imported raw materials for production process. The only locally available raw material in the country is scrap metal, which the factories buy for between 2.80 Br and 3.20 Br a kilogram me. It is smelted and converted into bars and billets. The billets are used to make reinforcement bars. The bars are used to produce spare parts and simple machines like concrete mixers and vibrators. Since, the Ethiopian basic metal industry dependency of imported materials, results high material cost, reliability in foreign suppliers is problematic, supply chain system problems, delay in cleaning goods through custom are the major problems that faced in Ethiopia basic metal industries [30]. The survey study shows that, due to this and other influences most of basic metal industries are working below the normal achievable capacity installed. As a result , the performance and competitiveness of Ethiopian basic metal industries is poor.

IV. Results and Discussion

Under this section to investigated and analyses the challenges of basic metal industries in based on the data gathered from i. Interview, Field observation, Questioner and literature survey results are done. Since the researcher observed and assessed in Ethiopian basic metal industries, inanition to their potentials to begins to industrialization , there were a lot of problems were investigated related to production planning and control systems. Based on this investigations and results the problems are grouped into the following two groups i. Manufacturing and Related Problems and mismanagement and Human Resource Related Problems were investigated.

a) Manufacturing Process and Related Problems

A. Manufacturing planning and control: poor manufacturing planning and control causing waste in the production process, deficiency of control and monitoring; serious efforts to find solution to problem and to determine implementation were not there. In most of basic metal industries there were lack of product and market diversification and development.

B. Waste in manufacturing process, due to improper resource utilization, poor manufacturing sequence , poor effectiveness in labor utilization, have frequent movement during manufacturing process, a lot of wastes were seen in the industry. This results unnecessary loss of material and waste formation were occurred in most basic metal industries.

C. Problems plant lay-out, Facilities are expanding everyday as a result of changes in technology and innovation. Since facility layout must be flexible to cater to modern changes and pant lay -out is a dynamic rather than statistics concept meaning thereby if once done it is not perm ant in nature rather improvement or revision in the existing plant

lay out must be made over time. But most Ethiopian Metal and engineering industries dos not considered this points. As a result of improper plant layout most metal industries lost their competitive advantages.

D. Quality: lacks robust design is a design which is executed at pre production planning stages to manage the controllable factors which affect the product quality related to parameter, customer specifications, standards, lack of defect control, lack of effective defect and redundant work recording in order to find the way to reduce and control the problems.

E. Low production capacity and effectiveness: the challenges formulated because of improper production sequence, poor equipment arrangement(Raw materials, Tools and products). In addition to these the production capacity of basic metal industries are poor due to using old machine, idle machine (maintenance problems), problems in demand production (skill , financial constraints, number of machines, resource problems).

F. Lack of smooth service and support delivery : Lack of fast and smooth delivery of support and service is a key problem witnesses in the sector in particular the electric power supply interruption and supply problem has been witnessed extensively. Additionally failure to assist financial in the appropriate manner, shortage of foreign exchange, gaps and witness in logistic supply problems related with land supply and duties and tax levied in the products, law level of incentive for the sub sector.

b) Management and Human Resource Related Problems

1. Planning problems : lack of work plan, no goals set for operating purposes, problems indicators for organization management, high volume of backlog orders, high volume of raw materials inventory, problems finished products storing before delivering.
2. Problems management information system: in most basic metal industries were no management information system used , outdate, inaccurate data, not useful for assisting decision making and management, available data not being used for analysis and finding of solutions for problem or improving work performance, inability to measure or assess operating result or management in each division, inability to tell volume of defects in process, lack of communication for to acknowledge the organizations direction, policy and goals.
3. Insufficient skill levels of employee
4. Most companies have employ shop floor workers with low educational level. most workers have practical skill for specific product but the don't know, how to manage and coordinate and accomplished it. This results the quality and productivity problem in most company.
5. Lack of unity including poor coordination among clients and among different divisions, resulting in delays in delivery; poor communication among division also cause inability to meet the manufacturing goals.

Research development and the market research Problems:

In most basic metal industries there were no R & D, for doing design improvement to forecast the market situation. due to this there wear unbalanced demand and supply, problems to see different alternative/opportunities. But practical production planning is dependent on the available capacity and actual demand of products on the market. In particular, the actual demand of products governs the amount of production which can be sold without unnecessary finished goods build-up. As a result this alternative suggests that the actual sales plan of the company has to be developed after sufficient market assessment and sales forecasting.

6. Warehouse problems: Despite the new technologies in e-commerce, supply chain integration, quick response, just-in-time delivery and efficient consumer response that connect the manufacturing with the end customers, businesses are still struggling to eliminate the existence of a warehouse. The biggest problems in Ethiopian basic metal industries were the production sequence problem and space utilization in the warehouse. Thus in order to meet the customer's requirements warehouse needs to be properly coordinated and maintained.

c) Cause and effect Analysis

The problems that (findings) assessed in Ethiopian basic metal industries by different approaches are from the above major problems, we can also grouped into four Sub- main problems of the industries. These are

A. Problems of Management System and related issue (leader-ship, efficiency, Lack of unity including poor coordination, fitness to the work and position, skill, Wage, turnover, information exchange, Response to Requested Information, system).

B. Manufacturing Process (machine, method, product quality, Waste in manufacturing process, maintenance, production time, production sequence, cost, capacity, warehouse coordination, Shop floor Control, Incomplete Information for design work).

C. Problems In Facility Layout- Facility layout provides planning for the location of all machines, utilities, employee workstations, customer service areas,

material storage areas, aisles, rest rooms, lunch¬ rooms, drinking fountains, internal walls, offices, and computer rooms, and for the flow patterns of materials and people around, into, and within buildings to enhance performance and competitiveness of manufacturing industries [22]. Even though In the case of Ethiopian basic metal industries because of poor facility lay out systems, production capacity is reduced, high materials-handling costs, crowded space for production machines, lost labor, machine, and space utilization and productivity, Problems on OHS, inventory counts problems, due to non warehouse inefficient loading and unloading of shipping vehicles) were investigated in this study.

D. Resource (warehouse facility, R&D, Raw material, Finance, Inventory, Manpower, Lack of updated stock Status File).

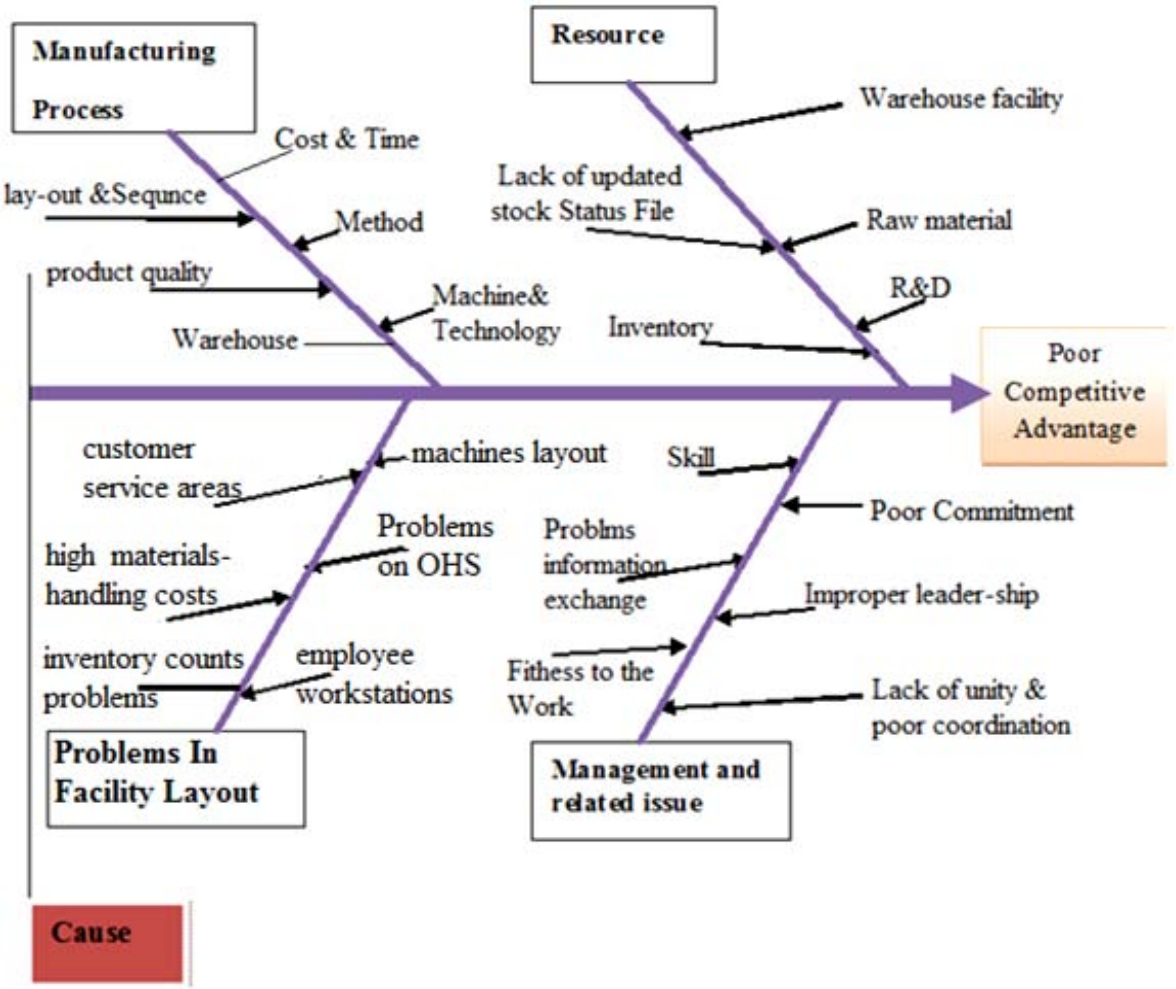


Figure 8: Cause and effect (fish bone) diagram

The above figure indicates that the various causes of each factor were determined and this leads poor competitive advantage of basic metal industries. from the above cause and effect diagram observe that, due to the four major problems and a lot of minor cases of these problems the performance and competitive advantage of basic metal industries are weakness and poor. However, successfully tackle and control the constraints of basic metal industries plays great role for the competitiveness of sector at national and global levels. Therefore, from numerous manufacturing industry performance improvement systems alternative, production planning and control has to be given the first priority. Since, improving production planning, controlling and related issue are a critical task for basic metals industries.

d) The way forward for strategies implementing PPC to Basic metal Industries

Therefore to attempt the above problems the production planning and controlling approaches should be apply to Ethiopia basic metal industries. Thus, for using implementing PPC to basic metal industries the following strategies are ways forward for sustainable basic metal industry development and competitiveness in the country.

While, there are a variety of considerations that go into the development and implementation of an

optimization model for manufacturing planning and control. Any planning problem starts with a specification of customer demand that is to be met by the production plan. In most contexts, future demand is at best only partially known, and often is not known at all. Consequently, one relies on a forecast for the future demand. To the extent that any forecast is inevitably inaccurate, one must decide how to account for or react to this demand uncertainty.

Although, a single PPC methods have limitations on performance and competitions of the firms. However to overcome the limitation of standard individual PPC systems such as MRP,MPS,CP or other, it is possible to develops a hybrid systems to combining two or more systems have an impact on changing environment. This is done combining the advantages of PPC elements (like MPS, ERP, MRP) simple logic and theory of constrains (TOC) ability to synchronize all production and material flow in a manufacturing firm. Because TOC is systematic management approach that focuses on actively managing those bottlenecks that impede a firm's progress toward its goal of maximizing profits and effectively using its resources.

Manufacturing workshop should be both flexible and effective nature to improve the competitive performance of the industries. both flexibility and efficiency through Product and Process Layouts. As a result basic metal industries should consider hybrid production/facility layout methods. Since the arrangement of the facility provides in such a way that, systematic and functional arrangement of different departments, machines, equipments and services in a manufacturing establishment.

The main objective of lay out design, that is to minimize distance traveled, is not always suitable for all the manufacturing industries. Some congestion in a specific area may have to be tolerated while maintaining minimum separation between facilities. Instead of criterion of minimizing total distance travelled, one may wish to minimize the maximum distance travelled. Since by considering this concept basic metal industries also should emphasis warehouse design and implementations.

V. Conclusion and Recommendations

a) Conclusion

This paper Analyzed the sector competitiveness, production planning and control systems of the Ethiopian basic metal industries. The performance and competitive advantage of basic metal industries are assessed in the context of production planning and control system. Since from the study the constraints, opportunities and the threats of basic metal industry sector performance and competitiveness are identified. Using field observation, research questions and Literature review methods problems in manufacturing process, Management problems (not more emphasis production, coordination), Maintenance problems(some machines not properly work, Improper production Sequence(in some section neither process nor product lay-out), Problems on wear house, Resource planning, fluctuating production volume (Market shortage, delay, some case performance problems occur) are investigated as the problems and constraints of Ethiopian basic metal industries. Since to tackle this problems proper production planning and controlling systems are considered and implementations are critical to basic metal industries so as to improve the performance and global competitiveness of the sector.

b) Recommendation

It will not totally be a question that the competitiveness of the basic metal sector in Ethiopia should increase this time. Nevertheless, the approach to attain better competitiveness situation is the challenging issue. As alternative means to sector improvement and growth, Ethiopian basic metal industries can implement production planning and control strategies as a better choice for sector performance and competitive advantages. Since, there has to be a strong commitment to responsible bodies towards implementation of the systems.

Future research study, use this study as reference for developing integrated production planning and control frame work to basic metal industries.

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Experimental Evaluation of Influence of Air Injection Rate on a Novel Single Slope Solar Still Integrated with an Air Compressor

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GJRE-A Classification: *FOR Code: 290501p*

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Abstract- In this paper, experimental evaluation and mathematical modeling of single slope hybrid solar still integrated with an air compressor at a different air injection rate within water basin. A compressor unit is used to inject air with different flow rate viz. 0.01, 0.03, 0.05 and 0.06 Kg/s in sea water within the basin area of hybrid solar still. Compressed air injection in water influences the performance parameters such as the temperatures and different modes of heat transfer rate. Rate of convective heat transfer between water and air reaches 2.2 W / m² ° C, between air and glass the convective heat coefficient equal 0.6 W/ m² ° C. The temperature difference between water and inner glass surface, with an addition of dry air inside the basin will enhance cumulative productivity (Pcu) of the hybrid single slope solar still and recorded 16 L/m².day. A comparative study of convective, evaporative heat transfer coefficients also has been reported.

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I. Introduction

The demand for potable clean water is increasing day by day due to the growing population and industrialization across all over the world. Air heating is one of the most important applications of solar energy [1]. Pandey [2] has given the bubbling effect of ambient air along with the simultaneous air bubbling and cooling of the glass cover, He has also compared an enhancement in distillate output which was reported 33.5 and 47.5 percent respectively on conventional single slope solar still. Al-Sulaiman et al. [3] studied the performance of two different configurations of deployment of an air heater before and between humidifier and dehumidifier (HDH) system. The study demonstrates that the HDH configuration with the air heater placed between the humidifier and the dehumidifier will give better performance and higher productivity as compared to the system when air heater is placed before the HDH. They have also reported the case when saline water is directly heated by the incident solar radiation and air enters into the humidifier through the nozzles, mixes with the water, gats humidified. Part of the air has condensed in the glass cover and the remaining air condensed in the dehumidifier system. The experiments have been carried out with the effect of solar air heater without turbulator and with the turbulator water heater. The maximum specific humidity gains were recorded 0.187 $kg_{water}/kg_{air.}$ Whereas the humidifier integrated with the solar air heater without turbulator has given maximum specific humidity gain of 0.11 kg_{water}/kg_{air}. The peak distillate of 20.61 kg/m^2 day were collected and reported [4]. Evacuated solar water heater integrated with the desalination unit by Kabeel et al. [5]. Air has been circulated either by natural or forced circulation (The effect of three types of forced circulating air: up, down and up-down) in conventional solar still. It has been reported that the forced down air circulation system gives a higher performance as compared to forced up, forced up-down and natural air circulation. Agouz [6] has experimentally evaluated the effect of water temperature, air flow rate and water level on productivity in HDH desalination system. He has observed maximum productivity of the system which reaches to 8.22 kg/h at water temperature 86 °C and air mass with a flow rate of 14 kg/h. An experimental investigation of HDH desalination system has been used for water and air heating simultaneously during the distillation process. The heated air and water from the collector supplied to the humidifier, where the air gets humidified and moves towards dehumidifier for condensation. The system ability was investigated by varying the flow rate of air, hot water in the humidifier and cooling water in a dehumidifier. The system distillation capacity enhances the air and water temperature and flow rate of air, hot water, and cold water. The highest productivity was recorded 12.36, 14.14 and 15.23 kg/m^2.day for the without turbulators, convex and concave turbulators in absorber plate respectively [7]. Kabeel et al. [8] investigated an experimental study of a double passes solar air collector–coupled modified solar still, with phase change material (PCM). A comparison between modified still and PCM, forced hot air injection and conventional still was conducted to evaluate the development in the freshwater productivity under the same atmospheric conditions. The experimental results have revealed that the daily freshwater productivity of the modified still higher than that of conventional solar still. The freshwater productivity reached 9.36 L/m^2 day

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for modified solar still, which was 108% higher than that of the conventional solar still. Nada et al. [9] were proposed a hybrid air-conditioning and HDH desalination system. The effect of fresh air ratio, space supply air temperature, outside air wet bulb temperature on the freshwater productivity, refrigeration capacity, compressor power and percentage of power saving are also presented. Their analysis shows that the locating of an evaporative cooler after the mixing of fresh air with return air remarkably increased the productivity of the distiller unit. Ghazy et al. [10] have undertaken an analytical study of a direct solar distillation system that combined solar still with an air heating humidification-dehumidification subsystem. Various procedures have been employed to improve the thermal performance of the integrated system by recovering heat losses from one component in another component of the system.

This research work depicts experimental evaluation results, viz. productivity, the behavior of heat transfer coefficients for active solar still hybrid with an air compressor for different flow rates of air within the hybrid single slope solar still integrated with the air compressor, to augment the production of drinking water.

II. Theoretical Background

Energy balance equations for evaluation of the heat and mass transfer coefficients within the hybrid solar still can be written as:

$$\frac{dT_g}{dt}=\frac{S_g}{(m_gC_{pg})}(\alpha_g(1-\varphi_g)G+(q_{ew}+q_{r,w-g}+q_{c,w-g})-q_{r,g-a}-q_{c,g-a}) \quad (1)$$

$$\frac{dT_f}{dt}=\frac{S_f}{(m_eC_{pe})}(q_{cw-f}+q_{ew,w-f}-q_{ev,f}) \quad (2)$$

$$\frac{dT_w}{dt}=\frac{S_w}{(m_wC_{pw})}((1-\alpha_g)(1-\varphi_g)\alpha_wG+q_{c,b-w}+q_c-q_{r,w-g}-q_{ew}-q_{c,w-g}-q_{r,w-f}-q_{ew,w-f}-q_{c,w-f}) \quad (3)$$

$$\frac{dT_b}{dt}=\frac{S_b}{(m_bC_{pb})}((1-\alpha_g)(1-\varphi_g)(1-\alpha_w)\alpha_bG-q_{c,b-w}-q_{losses}) \quad (4)$$

$$\frac{dm_e}{dt}=\frac{q_{ew}}{L_v} \quad (5)$$

MATLAB software is used for evaluation of different mode of heat and mass transfer (conduction, convection, radiation, and evaporation), variation in temperature within the distiller unit and the distillate flow rate. In the forced convection mode, the relation between Nusselt (Nu), Reynolds (Re) and Prandtl number (Pr) was given by [11]

$$\mathrm{Nu}=\frac{h_{cw}\,L}{k_i}=0.683\,\mathrm{Re}^{0.466}\mathrm{Pr}^{1/3} \quad (6)$$

Where, h_{cw} is the convective heat transfer coefficient that can be evaluated as,

The evaporative heat transfer coefficient (h_{ew}) can be written as [11]:

$$\frac{h_{ew}}{h_{cw}}=\frac{L_v}{c_p}\frac{M_w}{M_a}\frac{1}{P_T} \quad (7)$$

The ratio of the heat transfer coefficient and the mass transfer coefficient is equal to the specific heat per unit volume at a constant pressure of the mixture. Either the Lewis relation [12].

$$\frac{h_{ew}}{h_m\rho_fC_p}=1 \quad (8)$$

Therefore,

$$\frac{m_e}{A}=h_m(\rho_w-\rho_g) \quad (9)$$

Substituting Eqs. 7 and 8 in Eq.9 one can get.

$$\frac{m_e}{A}=\frac{h_{cw}.M_g}{\rho_fC_pR.T}(P_w-P_g) \quad (10)$$

III. Construction of Experimental Setup

The test rig is made with the help of stainless steel material of 3mm thick plate, which has 0.4 m^2 of the basin area. Lower and higher wall of distiller units are kept 480 mm and 610 mm high to make 30° inclination of the glass cover, considering latitude 33°52′53″ N and Longitude 10°05′53″ E of city Gabès. Transparent 4 mm thick glass material is used as a cover for the basin area with about 90% transmittance. Gasket rubber material is used in between basin top and glass cover and further sealed with window putty to

prevent the leakage of vapors from basin to ambient. The condensation water is collected in a collector channel, which is deposited at the lower end of the glass cover and small plastic pipe will be used to terminate collector channel. Fresh water is finally collected in an externally graded cylinder attached at the end discharge pipe. Feed raw/ saline water pipe has been connected to another side wall for feeding the brackish water into a distiller unit. Fig. 1a shows that the air compressor is connected to a screen equipped with holes for diffusing air into the seawater basin of distiller unit. It has been added in order to increase the evaporation rate of water containing in the basin by hybrid distiller unit. The air blower connected to an air screen, further it is connected to tap of a compressor.

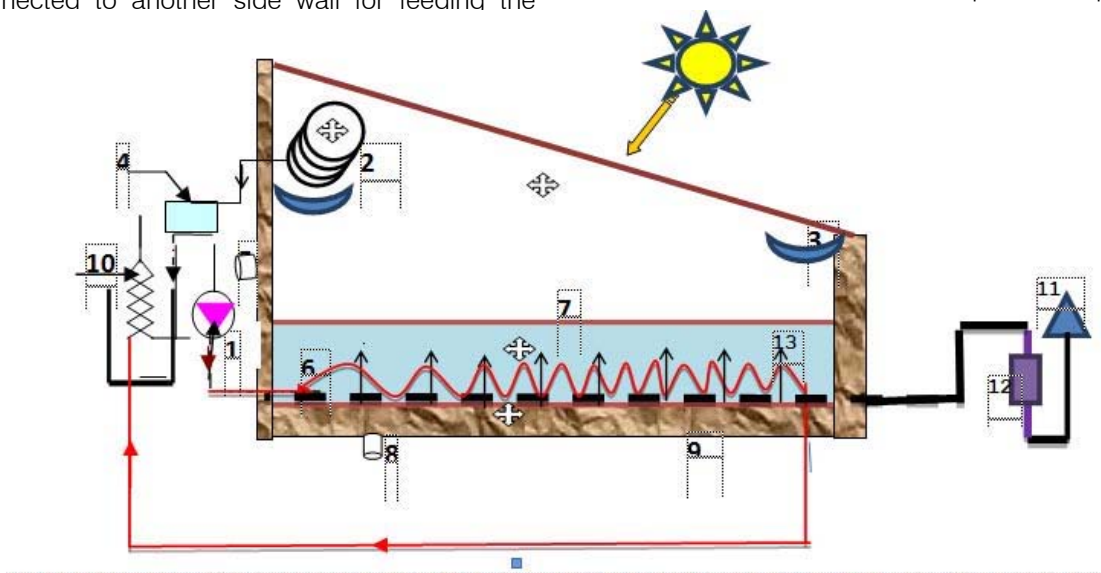

Figure 1a: Schematic arrangement of SSDHP with air pump

Figure1b: Actual photograph of SSDHP with air pump

Different parameters viz., air flow rate, water temperature, water level and relative air humidity and temperature within the basin inlet and on the water surface, were recorded during the experiments. The water temperatures in the basin were also measured using the thermometer-Pt100 which works in the range from −20 to +260°C with an uncertainty of 2.6%. The relative humidity and temperature of air streams were measured using 2 thermo-hygrometers which work in the range from 0 to 100% RH and from−40 to+120°C and its uncertainty is 1.4% tabulated in Table 1, Table 2 shows operating characteristics of different components.

Table 1: Details of measuring equipment and its range along with their accuracy

Measuring Equipments	Number	Range	Accuracy
K-type thermocouple	5	-200to1250°C	-0.2°C to+2°C
Digital differential pressure manometer	2	(+-)2bar	-2% to +2%
Digital thermo hygrometer	2	0% to 100% RH	-1.4% +1.4%RH
Thermometer-Pt100	4	−20 to +260C	2.6%.

Tabel 2: Operating characteristics

Parameter	Symbol	Value	Unit
Mass of glass	m_g	10.12	kg/m²
Mass of water	m_w	20.6	kg/m²
Mass of basin	m_b	15.6	kg/m²
Calorific heat capacity of glass	C_{pg}	800	J/kg°C
Calorific heat capacity of water	C_{pw}	4178	J/kg°C
Calorific heat capacity of basin	C_{pb}	480	J/kg°C
Absorbability of cover glass	α_g	0.075	----
Water absorbability	α_w	0.05	----
Basin absorbability	α_b	0.95	----
Glass emissivity	ε_g	0.88	----
Water emissivity	ε_w	0.95	----
Basin emissivity	ε_b	0	----
Glass reflectivity	ρ_g	0.0735	----
Water	ρ_w	0	----
Basin	ρ_b	0	----
Thermal conductivity of basin	k_b	16.30	W/m°K
Thermal conductivity of losses	k_i	0.039	W/m°K

IV. Experimental Procedure

The experimental setup is designed and constructed to investigate the effect on the productivity of hybrid solar still at a different flow rate of air within the test rig through compressor unit. While the experimentation temperature of the glass cover, water, and evaporator was recorded with the help of K type thermocouple, whereas the flow rate of air was recorded with the help of Rotameter and control with the help of regulatory valve. Distillate output is recorded with the help of graduated cylinder on an hourly basis. Each series of experiments were conducted for four different air flow rates (0.01, 0.03, 0.05 and 0.06 kg/s) at a constant water level of 10 cm. Incident solar radiation is recorded with the help of pyranometer.

V. Economic Analysis

Using economic analysis, estimation of the cost of one-litre distillate water has been made. In addition to the capital cost (P) of the hybrid solar still, other parameters such as sinking fund factor (SFF), annual salvage value (ASV), annual maintenance cost (AMC), and interest rate per year should be also considered. At this stage, the Capital recovery factor (CRF) is defined in terms of the interest per year i and also the number of life years of the system n [13,14]

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1} \tag{11}$$

The interest per year i and the number n of life years of the system are assumed 12% and 10, respectively.

Fixed annual cost (FAC) becomes:

$$\mathrm{FAC} = \mathrm{P(CRF)} \tag{12}$$

Where, P is the capital cost of solar still. The capital cost includes the cost of the hybrid solar still and air compressor as well as the costs of labor cost (for the active system). In this work the capital cost P becomes 1026.$ By taking the salvage value of system S equal to 20% of capital expressed respectively as [15]:

$$SFF = \frac{i}{(1+i)^n - 1} \tag{13}$$

Sinking fund factor (SFF) and annual salvage value (ASV) can be

$$ASV = (SFF)S \quad (14)$$

$$\text{For, } S = 0.2P \quad (15)$$

Sinking fund factor (SFF) and annual salvage value (ASV) can be for the passive unit, 0.0569 and 0.1769 $ (by considering 205.20 $ for the pump price) for the active one. The AMC which is annual maintenance operational cost of the system consists of collecting the fresh water, cleaning the glass cover, washing inside the unit to remove the deposited salt, and maintenance of DC fan. Here, 15% of fixed annual cost is considered as maintenance cost:

$$AMC = 0.15(FAC) \quad (16)$$

Therefore the annual cost (AC) is:

$$AC = FAC + AMC - ASV \quad (17)$$

Finally, the cost of fresh water per liter can be calculated as:

$$CPL = \frac{AC}{M} \quad (18)$$

Where M is the average annual yield of the solar still, Cost per liter of fresh water is shown in Table.3 for the hybrid distiller unit with and without an air compressor.

Table 3: Distilled water cost calculation

Type of distiller	Annual production, Kg	Annual cost ($)	Cost per liter of fresh water/$
With air compressor	5840	197.13	0.031
Without air compressor	3285	154.43	0.047

VI. Result and Discussion

During working hour incident solar radiation on glass cover surface was recorded with the help of pyranometer for different air velocity during the test days, shown in Fig.2. It is observed that the maximum solar incident radiation on glass cover during 12 h and 14 h around 900 W/m ^{2} for all air velocity.

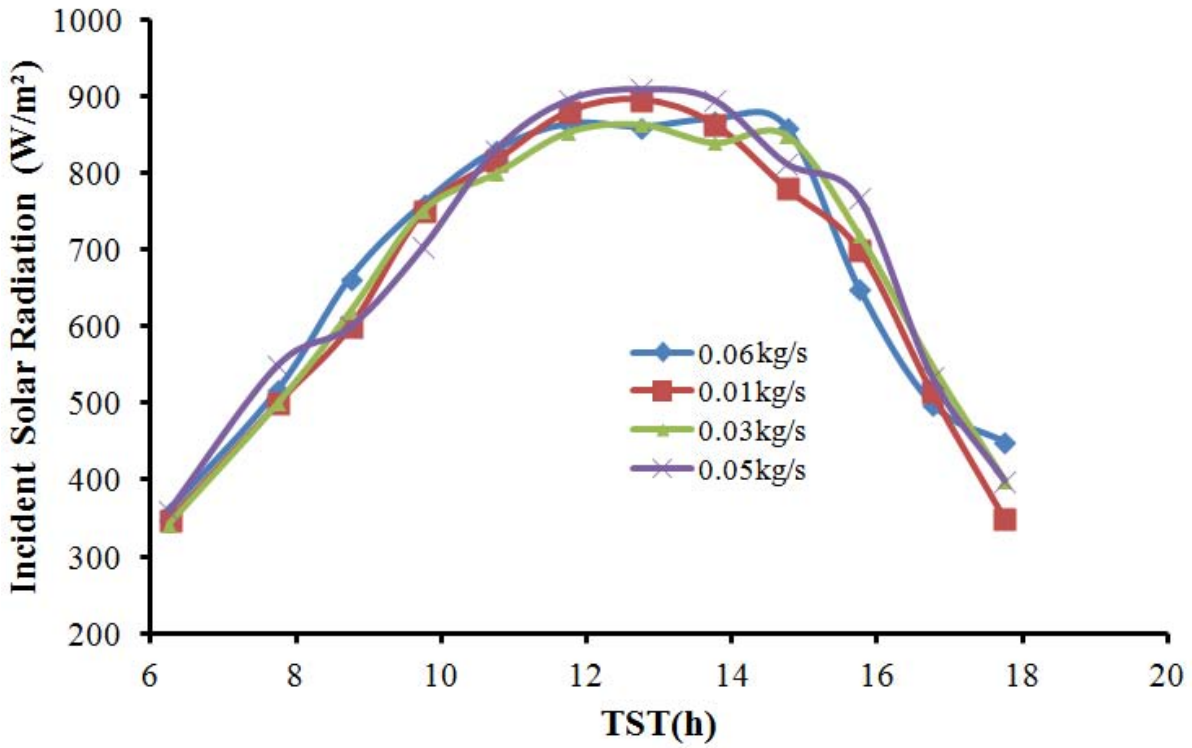

Figure 2: Variation of experimental solar flux with True Solar Time

Variation of water temperature at a different flow rate of air with respect to the time is shown in Fig. 3. It shows that the water temperature initially increases as solar radiation increases and further decrease as per the incident radiation.

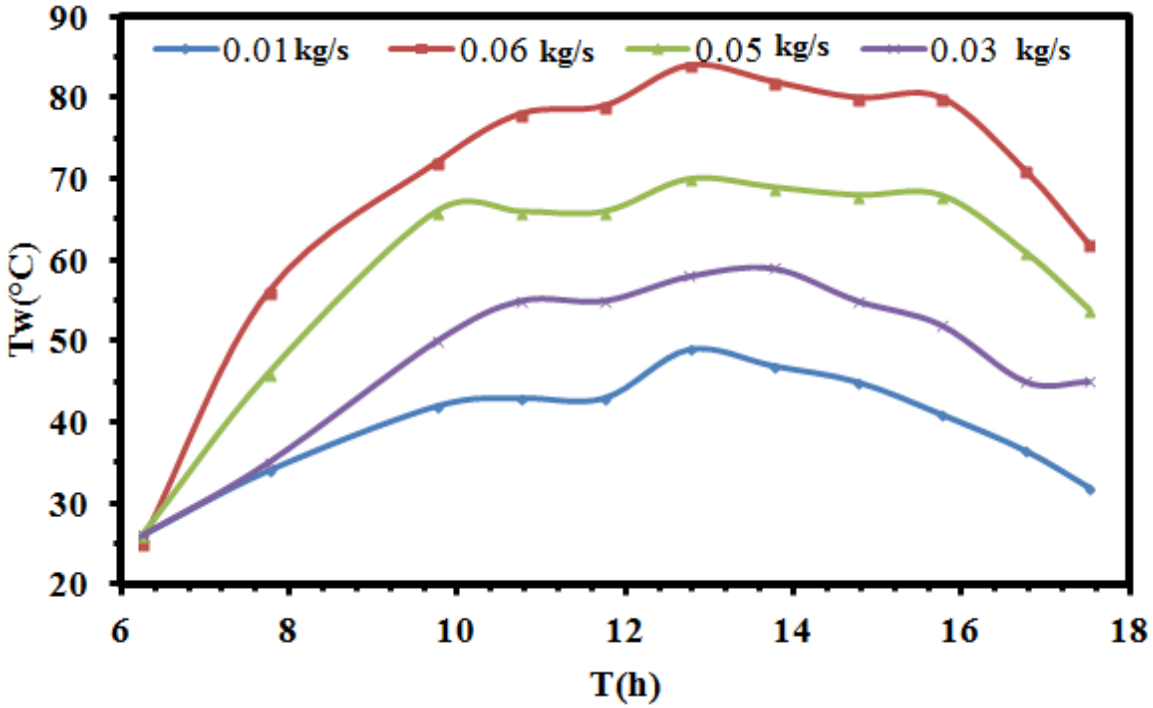

Figure 3: Variation of water temperature at a different flow rate of air with respect to time

The temperature of water ranged from 45.7°C to 89°C with airflow rate 0.06 kg/s and reaches its maximum value at 13 hours. It has been observed that the temperature of water starts to decline with air flow rate increases (70°C). Whereas glass temperature decrease due to the enrichment of air flow rate.

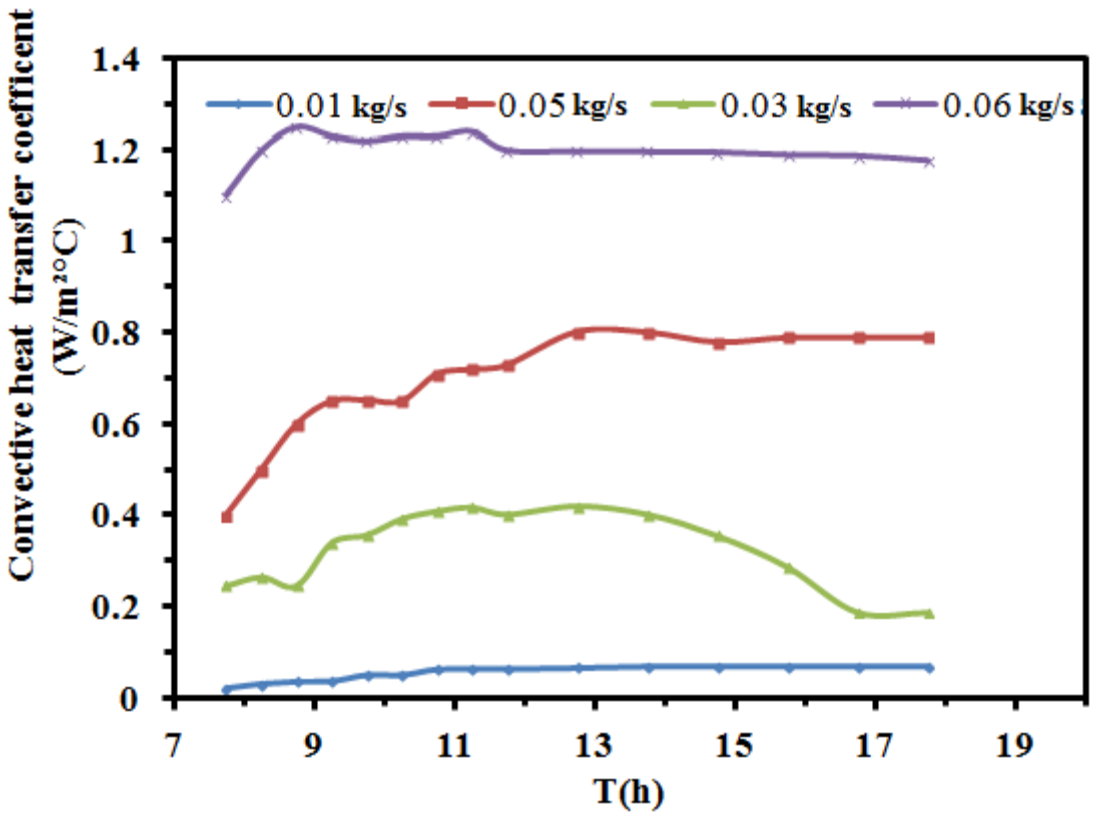

Figure 4: Variation of convective heat transfer coefficient at a different flow rate of air with respect to time

The convective heat transfer coefficient between the water surface and the flowing air at a different flow rate of air has been evaluated and shown in Fig.4. Maximum heat convective heat transfer coefficient is recorded 0.0698 W/m²°C, 0.42 W/m²°C, 0.803 W/m²°C and 1.25W/m²°C at air flow rate of 0.01 kg/s, 0.03 kg/s, 0.05 kg/s and 0.06 kg/s respectively. It has been recorded 34. 71%, 40.81%, and 10.83% higher as compared to the air flow rate of 0.01 kg/s, 0.03 kg/s, and 0.05 kg/s respectively. Convective heat transfer coefficient at an air flow rate of 0.06kg/s will maintain its lead throughout the experimentation which causes to higher yield as compared to the lower mass flow rate of air. The convective heat transfer coefficient between the water surface and the flowing air at a different flow rate of air has been evaluated and shown in Fig.3. Maximum heat convective heat transfer coefficients are recorded 0.0698 W/m²°C, 0.42 W/m²°C, 0.803 W/m²°C and 1.25W/m²°C at air flow rate of 0.01 kg/s, 0.03 kg/s, 0.05 kg/s and 0.06 kg/s respectively. It has been recorded 34. 71%, 40.81%, and 10.83% higher as compared to the air flow rate of 0.01 kg/s, 0.03 kg/s, and 0.05 kg/s respectively after the third hour of the time. Convective heat transfer coefficient at an air flow rate of 0.06kg/s will maintain its lead throughout the experimentation which causes the higher yield in comparison with the lower mass flow rate of air.

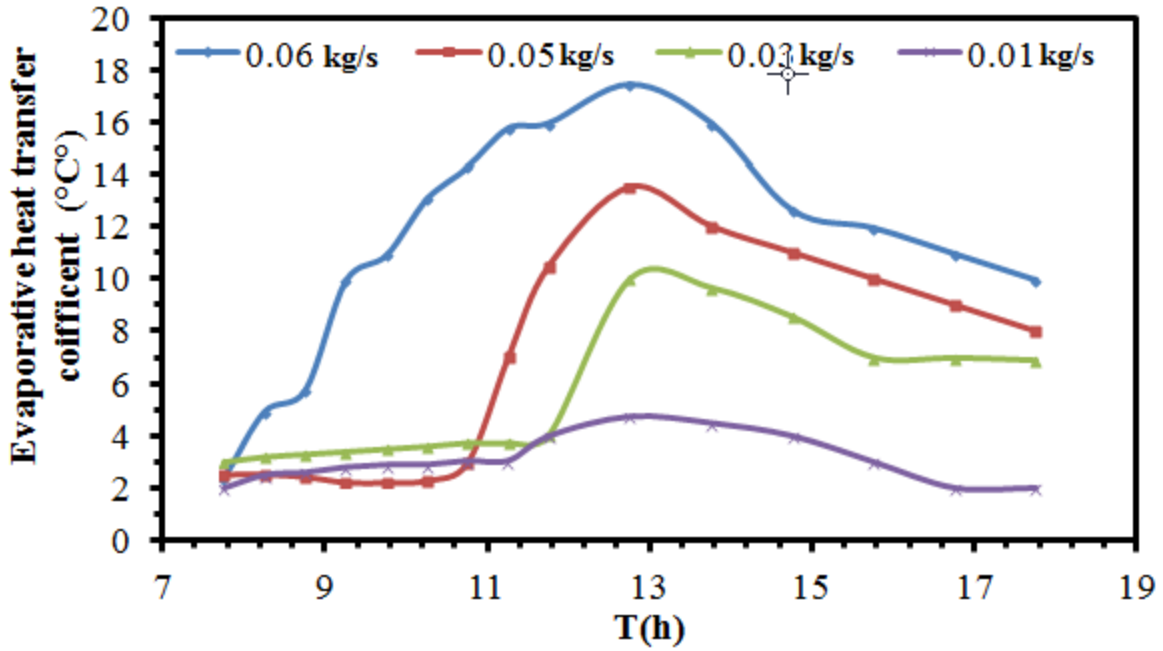

Figure 5: Variation of evaporative heat transfer coefficient at a different flow rate of air with respect to time

Variation in the evaporative heat transfer at different air flow rate of air at a one-hour interval of time is evaluated and shown in Fig.5. Which clearly shows that evaporative heat transfer coefficient during the mass flow rate of air 0.06 kg/s is higher as compared to the lower flow rate of air. It also depicts that enhancement of the flow rate of air will boost the evaporative heat transfer coefficient which results in higher yield. An evaporative heat transfer coefficient record 74.4%, 35.19% and 24.57% higher at flow of air 0.06 kg/s as compared to the air flow rate of 0.01 kg/s, 0.03 kg/s and 0.05 kg/s respectively.

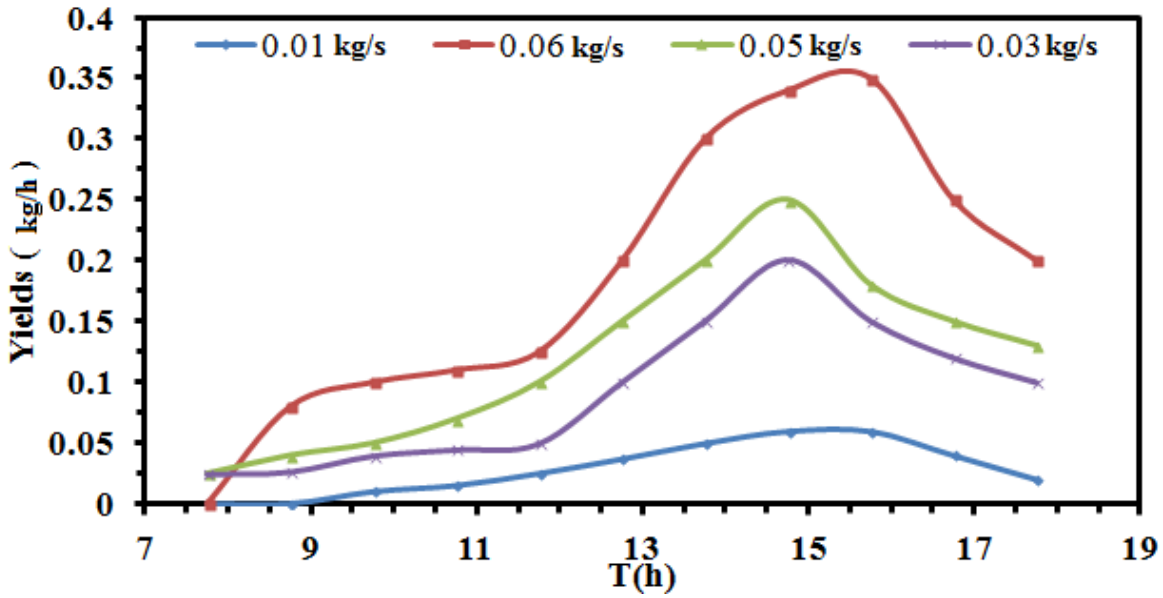

Figure 6: Variation of yields due to different air flow rate with respect to time

Effect on the yield of active solar still hybrid with an air compressor with corresponding time interval is shown in Fig.6. after a one-hour interval of time test-rig fed with an air of 0.06kg/s maintain a significant lead in distillate out as compare to the other those are fed with a lower flow rate of air. Throughout experimentation hybrid solar still integrated with an air compressor fed with 0.06kg/s air flow rate maintain its superiority over the others and maximum yield recorded 0.6 kg/h, 0.2kg/h, 0.25kg/h and 0.35kg/h at an air flow rate of 0.01 kg/s, 0.03 kg/s, 0.05 kg/s and 0.06 kg/s respectively. At eighth hour interval of time test rig which has air flow rate of 0.6 kg/s will give 48.333%, 13.3% and 94.44% higher yield as compared to the other cases of 0.01 kg/s, 0.03 kg/s, and 0.05 kg/s respectively.

VII. Conclusion

Influence of variation in air velocity within the hybrid solar still will greatly influence the production rate of the newly developed hybrid solar still. The rate of heat and mass transfer is enhanced due to the formation of water bubbles within the distiller unit whereas fall in basin water temperature observed due to increase in wind flow rate. But the overall productivity of distiller unit was significantly improved as compared to hybrid solar still without air.

Nomenclature

Cp: specific heat of air, J/kgK
h_{cw} : Convection heat transfer coefficient, W/m.K
h_{ew} : Evaporative heat transfer coefficient, W/m.K
hm: Mass heat transfer coefficient, W/m.K
k : Thermal conductivity.W/m.K
L: Specific length, m
L_v : latent heat , W/kg
M: Molar weight, mol/g
me : Specific mass, kg/m
Nu: Nusselt Number
Re : Reynolds Number
P : Pressure, N/m^2
Pr : Prandtl Number
S: Surface, m^2
T_w : Water temperature, ^oC
T_g : Glass temperature, ^oC

Induce

a : air
b : basin
cw : Convection,
ew : Evaporator
g : Glass
w : Water

symbol

ρ: Reflectivity
β : Inclination °
μ : dynamic viscosity KJ/m°K
Δ : difference
λ : Thermal conductivity W/m°K

Cost nomenclature

As: Area of basin in solar still m^2
AC: Annual cost
AMC: Annual maintenance operational cost of the system
ASV: Annual salvage value
CPL: Cost of fresh water ($/lit)
CRF: Capital recovery factor

ANNEXURE

Appendix A: Physical characteristics of humid air

$$Lv = 2.569\text{x}10^{5}\left(647.3 - T_{w}\right)^{0.38} \quad (1)$$

$$C_{p} = 999.2 + 0.1434\,T_{w} + 1.01\text{x}10^{-4}T_{w}^{2} - 6.7581\text{x}10^{-8}T_{w}^{3} \quad (2)$$

$$\lambda = 0.0244 + 0.6773\text{x}10^{-4}T_{w} \quad (3)$$

$$\rho_{w} = \frac{353.44}{T_{w} + 273.15} \quad (4)$$

$$\rho_{g} = \frac{353.44}{T_{g} + 273.15} \quad (5)$$

$$\mu = 1.718\text{x}10^{-5} + 4.620\text{x}10^{-8}T_{w} \quad (6)$$

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Numerical Simulation of Forced Convection through Metallic foam (HVAC Heating Coil Application)

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Abstract- The hydraulic and thermal performance of a porous medium generating of heat, considered as a HVAC heating coil, has been established using a numerical simulation. The used metallic foam is made from Copper and Aluminum with a porosity of 0.93. The channel has a rectangular shape with an establishment length equal to 5 times of the height.

The thermal equilibrium in the porous medium is considered between the fluid and solid, and he flow regime found is the Darcy regime for input speeds between 0.1 and 3 m / s.

The Aluminum metal foam has the higher temperature inside the porous medium compared to copper one, under the same conditions of velocity and heat flux.

Keywords: *HVAC, metallic foam, forced convection, heat transfer.*

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Ahmed Kouidri [α], Anis Khatir [σ], Abdennour Azzouz [ρ] & Pr Said Abboudi [ω]

Abstract- The hydraulic and thermal performance of a porous medium generating of heat, considered as a HVAC heating coil, has been established using a numerical simulation. The used metallic foam is made from Copper and Aluminum with a porosity of 0.93. The channel has a rectangular shape with an establishment length equal to 5 times of the height.

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The Aluminum metal foam has the higher temperature inside the porous medium compared to copper one, under the same conditions of velocity and heat flux. Since it is desired to heat through the hot battery, this characteristic can be interesting and it can help to save energy by adopting Aluminum as materials, Moreover, the aluminum foam has efficiency 5 times greater than that given by the copper foam.

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I. Introduction

The Heat transfer under convective boundary condition is common in heat exchangers [1]. The metal-foam-filled channels are proposed to increase the heat transfer area between hot and cold flows in plate heat exchangers [2]. The metallic foam is more and more used in thermal applications due to its convenient hydrodynamic and mechanic properties: porosity (in general≥ 90%), high permeability and strength.

Pei-Xue et al. [3]report that the local heat transfer increase with increasing in flow rate and it decrease along the channel. Their numerical results show that there is a difference between the fluid particle temperature and the solid one which demonstrate the importance of non- equilibrium model. Z.G. Qu., et al. [4] found that the flow resistance maybe decreases with high porosities, density of pores and the metallic foam thickness report. The optimal porosity correspond the maximum Nusselt number; the latter increases with decreasing in fluid-solid conductivity report. The results of Degan. G et al. [5] show that the permeability K has a significant influence on the convective heat transfer, where the heat transfer is best with high permeability values. Jeng, Tzer-Ming [6] present an experimental study of heat cooling of metallic foam blocs, they found that the Nusselt number may be intensified with factor varying between 3 and 5 compared to the smooth channel. Brahim MADANI et al. [7] indicate that the three-dimensional cellular structure of the foam acts as a mixing promoter. They report that the dispersion of the results obtained on similar metallic foams shows that the control and the understanding of the phenomena of flow in such media must pass through a thorough and precise analysis of their structures. The results of Hamadouche et al.[8] demonstrate that the insertion of metallic foam in turbulent flow participates in the enhancement of heat transfer with factor of 300% compared to the smooth channel. Kouidri at al. [9] characterized three metallic foam, with different surface roughness, their results show that the pressure drop increase from the smooth to the rough one, they report also that the permeability changes from type of flow to another.

The present work consists to studying the thermal and hydrodynamic performances of an HVAC Heating coil situated in air treatment station. The latter is considered as a porous medium (metal foam) generating of heat. The physical problem is simplified to a flow between two adiabatic plates, through a porous medium, generating of heat. The tested metallic foams are made from Copper and Aluminum.

II. Problem Description

We consider an air flow between two horizontal plates. The channel is divided into three parts: inlet, outlet and the porous medium generating of heat (Fig 1). The first zone (inlet) has an establishment length L1 equal to 5H. The second zone, which has a length L2-L1, is considered as HVAC heating coil with a porous medium. The third zone (outlet) has an establishment length of 5H. We noted that the height H is equal to 1cm and the thickness of metallic foam is equal to cm. The upper and lower walls are assumed to be adiabatic.

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The used metallic foam was characterized by Kouidri et al. [9]. The Aluminum foam has the same geometric characteristics to the copper one.

Figure 1: Physical problem and computational domain.

Table 1: Geometric characteristics of the used metallic foam [9].

	Dp (mm)	Dlig (mm)	Ligament type	Porosity (%)	PPI	Permeability
Copper	1.2	0.187	Triangular	93	18	6.40E-09

III. Mathematical Formulations and Modeling

The used method to derive the discretization equations is the finite volume with the SIMPLE algorithm. The structural mesh is adopted with 25000 nodes after studying the sensibility of mesh.

The conservation equations for a two-dimensional stationary laminar flow, considering the thermal equilibrium, taken from the reference [10] are presented in the equations: 1, 2, 3 and 4.

Mass conservation equation

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \tag{1}$$

Momentum conservation equation

$$\rho_f\left[u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}\right]=-\varepsilon^2\frac{\partial p}{\partial x}+\left[\frac{\partial}{\partial x}\left(\varepsilon\mu_P\frac{\partial u}{\partial x}\right)+\frac{\partial}{\partial y}\left(\varepsilon\mu_P\frac{\partial u}{\partial y}\right)\right]-\rho_f\frac{F\varepsilon^2}{\sqrt{K}}\left(\sqrt{u^2+v^2}\right)u \tag{2}$$

$$\rho_f\left[u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}\right]=-\varepsilon^2\frac{\partial p}{\partial y}+\left[\frac{\partial}{\partial x}\left(\varepsilon\mu_P\frac{\partial v}{\partial x}\right)+\frac{\partial}{\partial y}\left(\varepsilon\mu_P\frac{\partial v}{\partial y}\right)\right]-\rho_f\frac{F\varepsilon^2}{\sqrt{K}}\left(\sqrt{u^2+v^2}\right) \tag{3}$$

Where F : Forchheimer Coefficient

Energy Equation

$$\rho_f\left[u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}\right]=\left[\frac{\partial}{\partial x}\left(\frac{k_{effective}}{cp_f}\frac{\partial T}{\partial x}\right)+\frac{\partial T}{\partial y}\left(\frac{k_{effective}}{cp_f}\frac{\partial T}{\partial y}\right)\right]+S \tag{4}$$

Boundary conditions

The boundary conditions, in dimensional form, are represented below:

- x =0 0 < y < H (Channel inlet)

$$T = T_0,\ u = U_0,\ v = 0$$

- x =L 0 < y < H (Channel outlet)

$$\frac{\partial u}{\partial x}=0, \qquad \frac{\partial T}{\partial x}=0$$

- y = 0, y = H, 0< x < L

$$\frac{\partial T}{\partial y}=0, \qquad u=v=0$$

An explicative scheme of the boundary conditions is represented in Fig. 2.

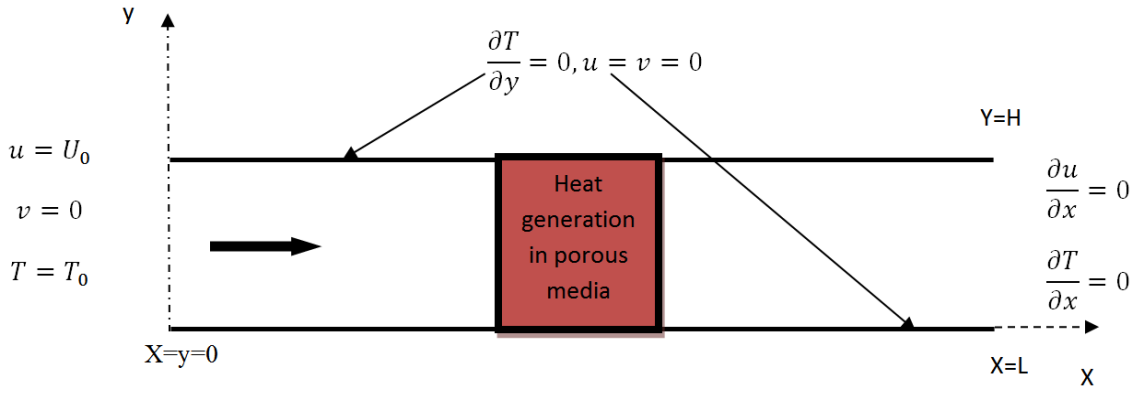

Figure 2: Boundary conditions for the physical problem

The permeability is used as a characteristic length in Reynolds equation (Eq. 5):

$$\mathrm{Re} = \frac{\rho v \sqrt{\kappa}}{\mu} \quad (5)$$

The same for the friction factor f which is calculate on basis of permeability (Eq.6)

$$f = \frac{\Delta P \sqrt{K}}{L \rho V^2} \quad (6)$$

The efficiency of the HVAC heating coil is given by the Eq. 7:

$$\dot{\varepsilon} = \frac{Q_{abs}}{Q_{gen}} \quad (7)$$

Where Qgen represents the heat flux generated in the porous medium (Heating coil), it equals to 5000000 W/m3. And Qabs represents the heat flux absorbed by the fluid between the inlet and outlet of the porous medium. It is calculate on basis of Eq. 8:

$$Q_{abs} = m * C_p * (T_o - T_i) \quad (8)$$

IV. Results

a) Velocity profile

Figure 3 (a) shows the velocity profile at the inlet of the channel, which is established before reaching the entrance of the porous medium, where the maximum velocity is at the center of the Y axis. We noted that the length of the channel at the inlet is 5 times greater than its height, which is sufficient for the establishment of a laminar regime.

Figure 3 (b) shows the velocity profile inside the porous medium, which is flattened; this is due to the slow flow caused by the porous medium (metal foam).

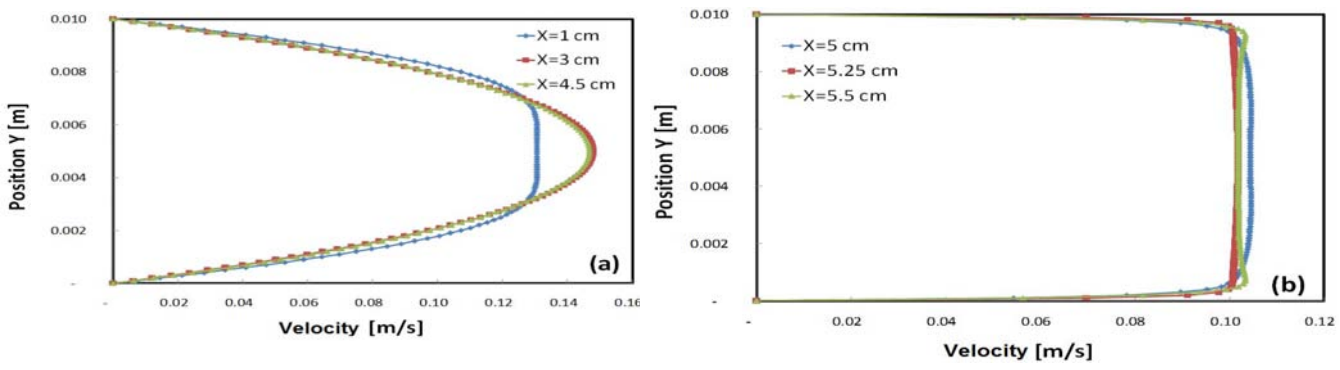

Figure 3: Velocity profile, (a): at the inlet of channel, (b) in the porous media

b) Pressure drop

Figure 4 shows the pressure drop, along the porous medium, for Aluminum and copper metallic foam. It is obvious that the two metallic foam samples present the same pressure drop because they have the same geometric characteristics. The pressure drop vary linearly with the velocity. Using a linear regression, the correlation between the pressure drop and the velocity may be writing following Eq. 9:

$$\frac{\Delta P}{\mathrm{L}} = 2773.5\, V \qquad (9)$$

The form of this equation is similar to the one given by Darcy [11] (Eq. 10), which demonstrate that the flow regime is Darcian.

$$\frac{\Delta \mathrm{P}}{L} = -\frac{\mu}{\mathrm{K}} V \qquad (10)$$

In the present simulations, the constant (μ/K) is equal to 2773.5 as is shown in Fig. 4

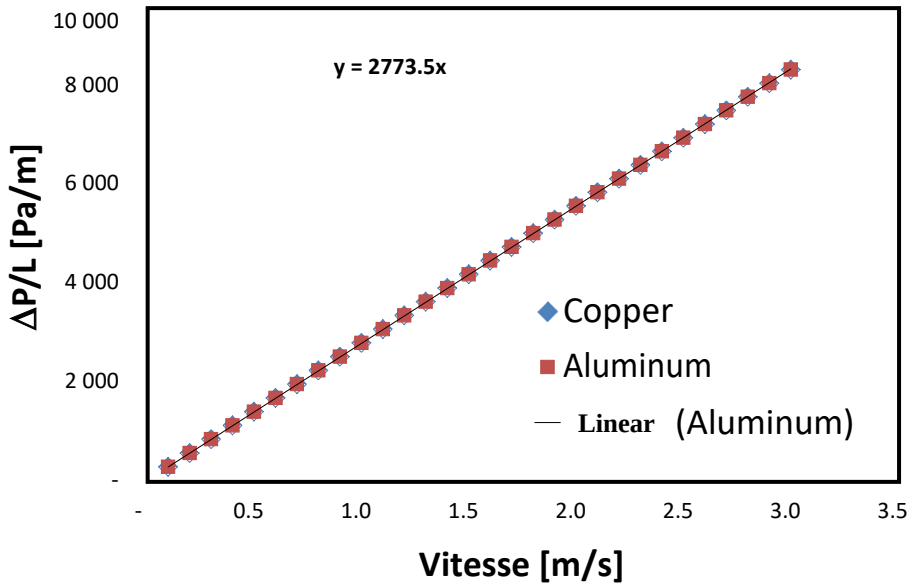

Figure 4: Pressure drop along the porous media for Copper and Aluminum metallic foam

c) Friction factor

The friction factor versus Reynolds number is represented on FIG. 5 (a), using a logarithmic scale, the latter decrease linearly with Reynolds number as it is known in laminar flow (Moody diagram). We noted that the Darcy regime in a laminar regime.

Physically, the friction factor is proportional to the inverse of Reynolds number. a representation of friction factor versus 1/Re is demonstrated on Fig 5 (b). Using a linear regression, the friction factor may be correlated following Eq. 11, with a correlation factor equal to 1

$$f = \frac{217}{R} \qquad (11)$$

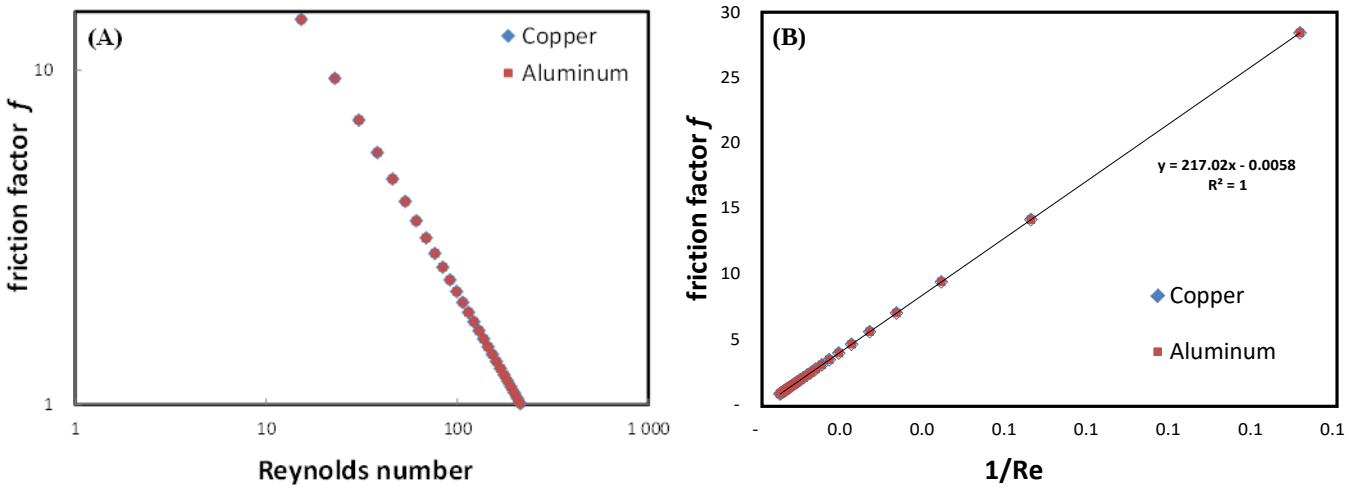

Figure 5: Friction factor through the metallic foam, (A) versus Re, (B) versus 1/Re

Figure 6 shows a comparison between the present simulations and the data given by the literature [9, 12], for different material of metallic foam, the results are closed to those given by Kouidri et al. [9], this is due to the fact that the same geometric characteristics were introduced in the present simulations.

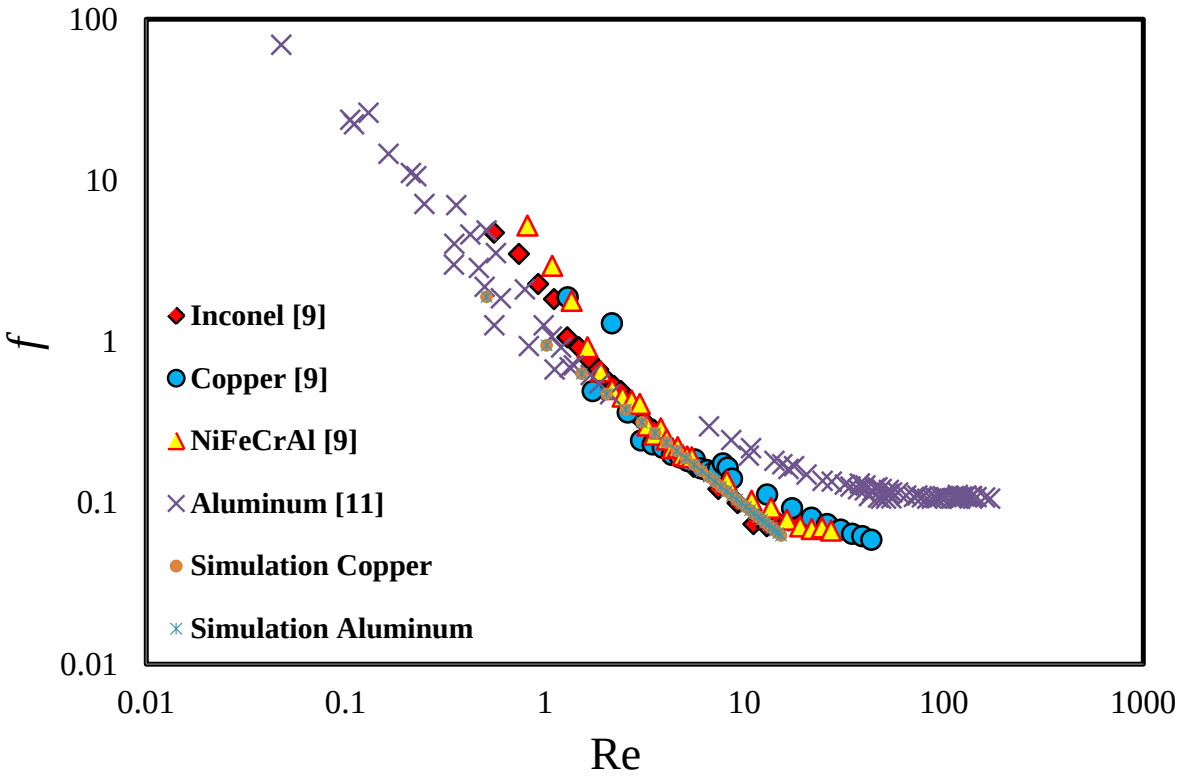

Figure 6: Comparison of present simulations with the literature data

d) Temperature distribution

Figure 7 presents the temperature distribution along the porous media, averaged on the Y axis, It is obvious that the evolution is logarithmic along the porous medium, for the two metallic foam samples.

In the same flow conditions, velocity and heat flux, the Aluminum sample gives the highest temperature; it can be interpreted by its calorific capacity which is more important compared to the copper one. This characteristic of Aluminum metallic foam is very important in HVAC heating coil, because it permits to have an important blowing temperature with minimum of dissipate energy.

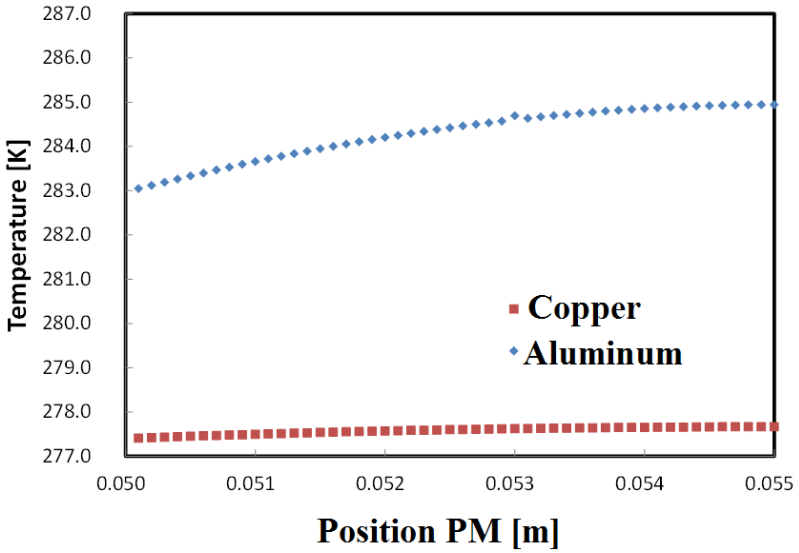

Figure 7: Average temperature along the porous media (V=1.1 m/s)

e) HVAC heating coil efficiency

The HVAC heating coil is calculated on basis of Eq. 7, presented in previous paragraph.

Figure 8 depicts the HVAC heating coil (made from porous media) efficiency, we remark that the efficiency in the case of Aluminum foam increase from 40% to 50% depending on the inlet velocity. The latter is constant for the velocity > 1.5 m/s.

On other hand, the Aluminum foam gives an efficiency 5 times more important compared to the copper one, this is due certainly to its important calorific capacity.

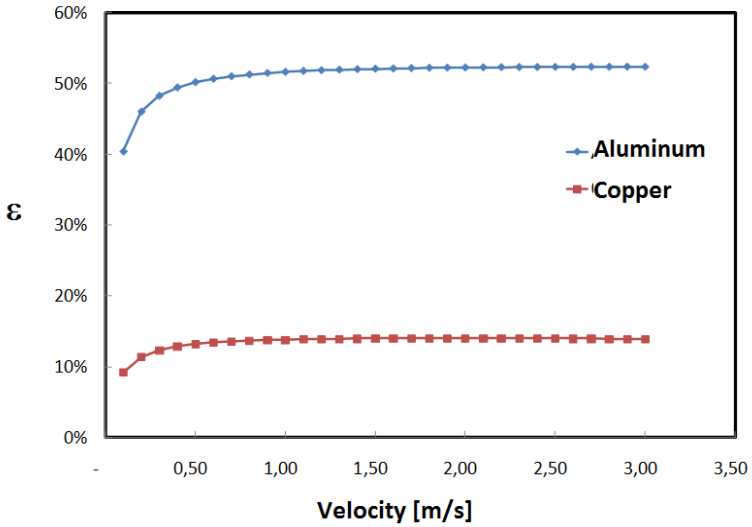

Figure 8: HVAC Heating coil efficiency for velocity inlet varying between 0.1 and 3 m/s.

V. Conclusions

The aim of this study is to present the hydrodynamic and thermal performances of HVAC heating coil. The latter is simulated by a porous medium, generating of heat. The metallic foam, made from Aluminium and copper, is used as porous medium.

The two metallic foam samples, Aluminium and copper, present the same hydrodynamic performance because they have a same geometric characteristics.

The metallic foam made from Aluminium permits to reach a blowing temperature significantly higher, compared to that given by the copper sample, for the same flow conditions. This can be interpreted by the large calorific capacity it has, compared to that of copper. Since the study is conducted on HVAC heating coil, this feature of Aluminum is interesting and saves energy.

Moreover, the Aluminum foam gives an efficiency 5 times more important compared to the copper one, this is due certainly to its important calorific capacity.

It should be noted that the efficiency of the porous heating coil, for both materials, remains unchanged beyond a velocity of 1.5 m/s.

NOMENCLATURE

C_P	Calorific capacity	(kJ/kg°C)	v	Velocity/y	(m/s)
F	Forchheimer coefficient	(-)	x	Position	(m)
f	Friction factor	(-)	Greek symbols		
H	Height	(m)	ρ	Density	
HVAC	Heating, Ventilation and Air-Conditioning	(-)	μ	Dynamic viscosity	
K	Permeability	(m^2)	ε	Porosity	
k	Thermal conductivity	(W/m°C)	Subscripts		
L	Length	(m)	abs	absorbed	
m	Flow rate	(kg/s)	f	fluid	
P	Pressure	(Pa)	gen	generated	
PPI	Pore per inch	(-)	i	inlet	
S	Source term	(W/m^3)	lig	ligament	
T	Temperature	(K)	o	outlet	
u	Velocity/x	(m/s)	p	pore	
			0	initial	

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After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
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The following entitlements are applicable to individual Fellows:

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Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

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1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

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Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

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References

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Key points to remember:

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- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

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Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

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To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

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- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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