# SHOT PEENING, COATING AND BOILING HEAT TRANSFER

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ABSTRACT

Effect of shot/grit peening on surface heat transfer coefficients of Boiler quality steel tube was studied. It was found that grit peening was beneficial in improving heat transfer characteristics, than shot peening. But when surfaces are coated with M-Seal compound, the heat transfer rate differed in a different way. It was observed that for heat flux upto $3x10^4$ k cal/h $M^2$ effect of coating and peening was equally beneficial, but for higher heat flux both coating and grit peening processes have shown lesser benefits. Similarly it was also observed that coating with M-Seal (Thermoset Polymer Coat) of 0.1mm thick coat has shown lesser improvement in heat transfer at higher heat flux as compared to grit peened tube. It is evident that if peening is done with shots using pressure peening system and then coated with thinner coat, there will be duel advantage of better corrosion fatigue resistance and higher heat transfer rates. Adverse effect of sharp notches produced by grits will be reduced by sperical shots which will not only reduces stress concentration but at high velocity it will give appreciable roughness and adequate adhesion of coat with similar improvement in heat transfer rate as that of grits.

KEYWORDS

Shot/grit peening, nucleate boiling, film boiling, surface heat transfer co-efficient and wettability.

## INTRODUCTION

Pool boiling has three distinct regiemes of boiling Viz. Convective, nucleate and film boiling. It is needless to say that surface condition plays an important role on heat transfer characteristics. Majority of the processes related to heat transfer utilise tubes of suitable size and material for required heat transfer rate and they normally operate in nucleate boiling range. Hence, any treatment to improve surface qualities which are useful in enhancing the heat transfer rate needs attention. Shot peening is one such method [1].

The two important factors which are having more impact on heat transfer rate of a surface are (a) Surface roughness, which favours rapid bubble formation by necleation at cavities i.e., nuclii and (b) Wettability. Since Controlled peening produces reproducible surface roughness it was decided to study the effect of shot/grit peening on boiling heat transfer rate.

## EXPERIMENTAL WORK

The composion of Boiler quality steel used was as mentioned below:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| C | = | 0.20% max | ; | Si | = | 0.1% - 0.45% |
| Mn | = | 0.35% - 0.8% | ; | P | = | 0.05% Max |
| S | = | 0.5% Max | ; | Mo | = | 0.25% - 0.65% |
| Harness of the tube | | HRA | | | | |

The syphonic shot peening machine reported earlier was used for peening [2].

The following were the conditions:

| | | | | | |
|---|---|---|---|---|---|
| Air pressure | = | 0.6M Pa | ' | Stand off | = 25 mm |
| Coverage | = | 98% | ; | Grit Size G-25 | |
| Surface roughness = 2.8 m | | | | | |

It was found that shot peening improved the heat transfer rate marginally, but there is a substantial improvement with grit peening. The probably reasons for this may be:

i. relative rough surface produced by the grit peening, than that of shot peening which favours rapid bubble formation.

ii. the capacity of the syphonic nozzle peening cabinet used may not be sufficient to give sufficient energy to the shots, for creating relatively same roughness as obtained by grit peening.

iii. another probably reason may be conical dents produced by grit peening for favourable nucleation.

Hence, it was decided to grit peen the samples for further study. Unless otherwise mentioned the results in the paper belong to grit peening only.

Boiling heat transfer test set-up reported earlier [3] was used for studying the effect on heat transfer rates. This method has inherant advantage that the test piece resmbles very closely to the actual working condition. Hence no correlating data/study is necessary.

Results are tabulated in table 1. It is clear that the boiling heat transfer rate was improved substantially at lower heat flux ranges. In order to study the effect of wettability. The sample was coated with M-Seal compound (MS 802 resin and MSH-274 Hardener) on outside and tested. It is evident from the results that the M-Seal coating also equally improves the heat transfer rate at lower heat flux ranges but rapidly decreases at relatively high flux ranges. But at the same range grit peened samples have shown steady improvement. This may be attributed to the fact that M-Seal coated surface due to non Wettability character may be suffering from vapour blanketing at relatively high heat flux range which normally reduce heat transferability. But wettable grit peened sample was able to maintain steady improvement in the above said range See fig.1 & 2(a),(b)&(c)

RESULTS AND DISCUSSION

It can be concluded that the heat transfer tubes may be grit peened and then coated for better heat transfer rates. Since the grit peening improves the surface for better adhesion of the coat and if by any chance coating fails the grit peened surface still gives improved heat transfer rates. Hence, grit peening of heat transfer tubes together with coating has duel benifit, provided the surface cavities do not act as active stress raisers. Polymer coats are not only favourable for corrosion resistance but also favours non wettability by which rate of bubble formation was promoted and gave increase in heat transfer.

The effect of grit peening on fatigue properties of Boiler quality steel may be studied in order to implement the above factor practically. Shot peening with pressure peening cabinate can also provide good adhesion of polymer coat and at the same times will avoid stress concentration. Therefore it is proposed that shot peening though gives marginal improvement in boiling heat transfer rate when used at higher velocity can replace grit peening and avoid the danger of stress concentration.

REFERENCES

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2. Sharma, M.C. and Jain, A.K., "A new type of nozzle developed for the study of the effect of shot size on intensity of peening under specified peening parameters", ICSP-1, 1981, pp 175-181.

3. Sharma, M.C. & Mubeen, A. "Heat transfer in internally peened tubes, Second International Conference on impact treatment processes, 1986, pp 127-133.

TABLE - 1    Boiling Heat Transfer test results

| S.No. | Primary heater voltage (V) | Heat input $Q=(\frac{V^2}{R})$ K.Cal/hr | Heat flux $q=Q/DL$ K.Cal/hm$^2$ | $T_1^o$ C | VIRGIN $(T_1-T_s)$ $dT_1$ | $h_1=q/dT_1$ K.Cal/hrm$^2$ $^oC$ | Percentage improvement |
|---|---|---|---|---|---|---|---|
| 1. | 130 | 357.435 | 23458 | 101.98 | 2.48 | 9447 | - |
| 2. | 140 | 414.540 | 27206 | 102.93 | 4.43 | 7930 | - |
| 3. | 150 | 475.875 | 31232 | 104.05 | 4.55 | 6861 | - |
| 4. | 160 | 541.440 | 35535 | 104.48 | 4.98 | 7131 | - |
| 5. | 170 | 611.235 | 40115 | 104.83 | 5.33 | 7519 | - |
| OUTSDIDE PEENED | | | | | | | |
| | | | | 100.57 | 1.00 | 23458 | 148 |
| | | | | 101.17 | 1.67 | 16291 | 105 |
| | | | | 102.17 | 2.67 | 11697 | 71 |
| | | | | 102.58 | 3.08 | 11537 | 62 |
| | | | | 102.75 | 3.25 | 12343 | 64 |
| M-SEAL COATED | | | | | | | |
| | | | | 100.50 | 1.00 | 23458 | 148 |
| | | | | 101.20 | 1.70 | 16004 | 102 |
| | | | | 101.93 | 2.43 | 12853 | 87 |
| | | | | 103.33 | 3.83 | 9278 | 30 |
| | | | | 104.21 | 4.71 | 8517 | 13 |

Primary heater resistance (R) = 40 ohms; Saturation temp. at atm, pr. of boiling water $(T_s)$ = 99.5; Cooling water temp. at inlet 38$^o$C and outlet = 60$^o$C; Flos = 0.5 1/min.

$h_1$ = Surface heat transfer coefficient for Virgin tube.

$h_2$ = -do- -do- outside peened tube.

$h_3$= -do- -do- M-Sseal Coated Tube (outside)

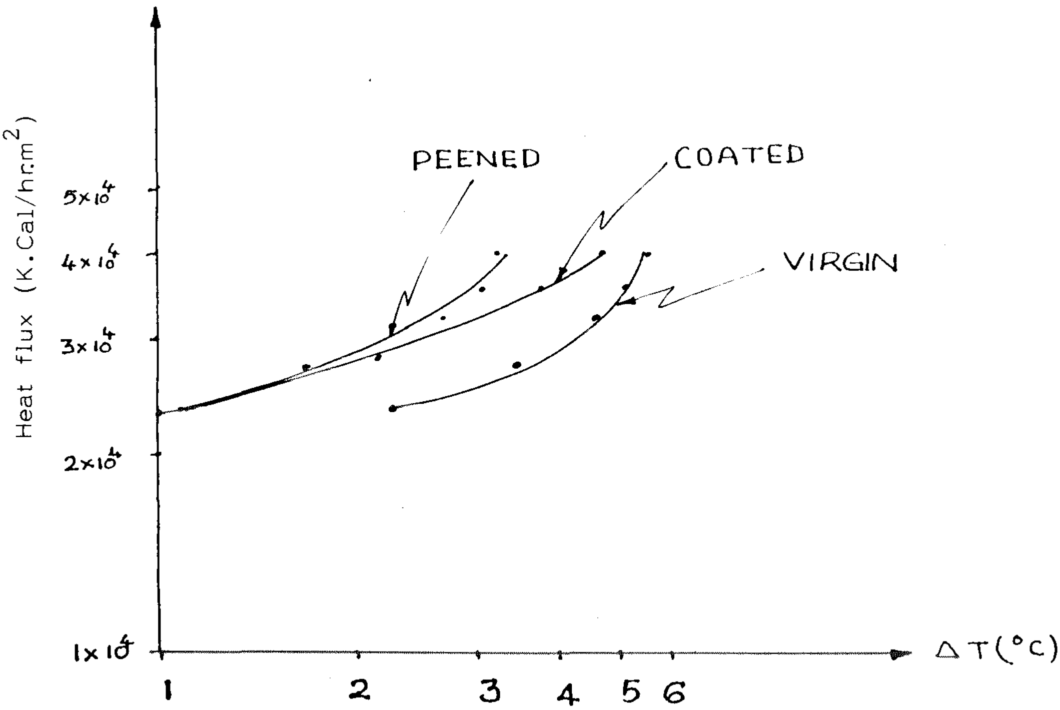


Fig.1 Heat flux Vs ΔT

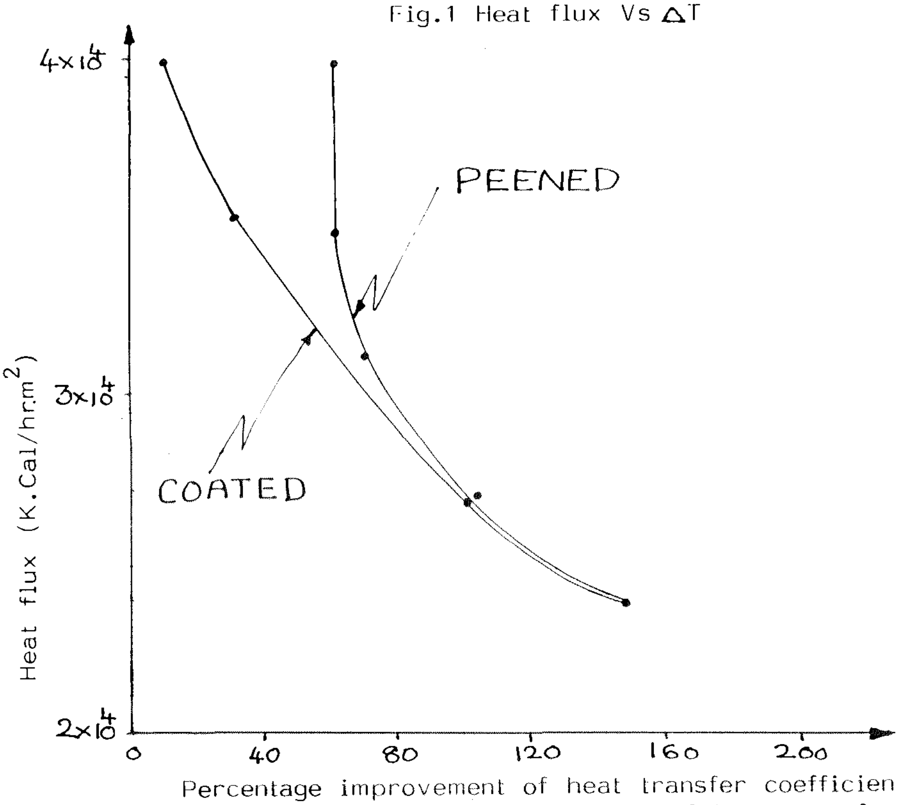


Fig.2 Heat flux Vs Percentage improvement of heat transfer coefficient

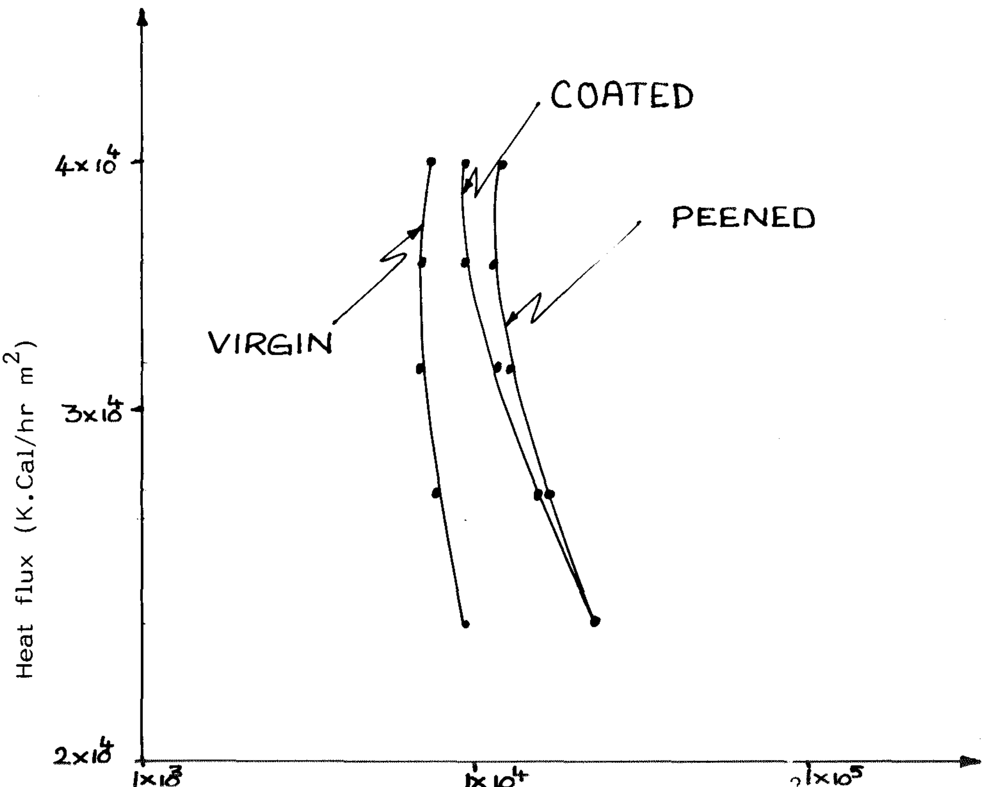


Fig.2(b) Heat flux Vs Heat transfer coefficient

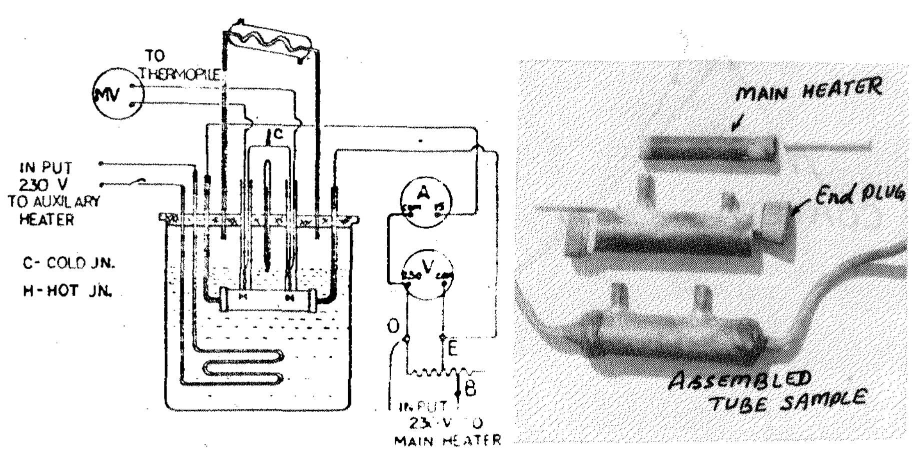


Fig.2(c) Experimental set up (Schematic) and Tube assembly