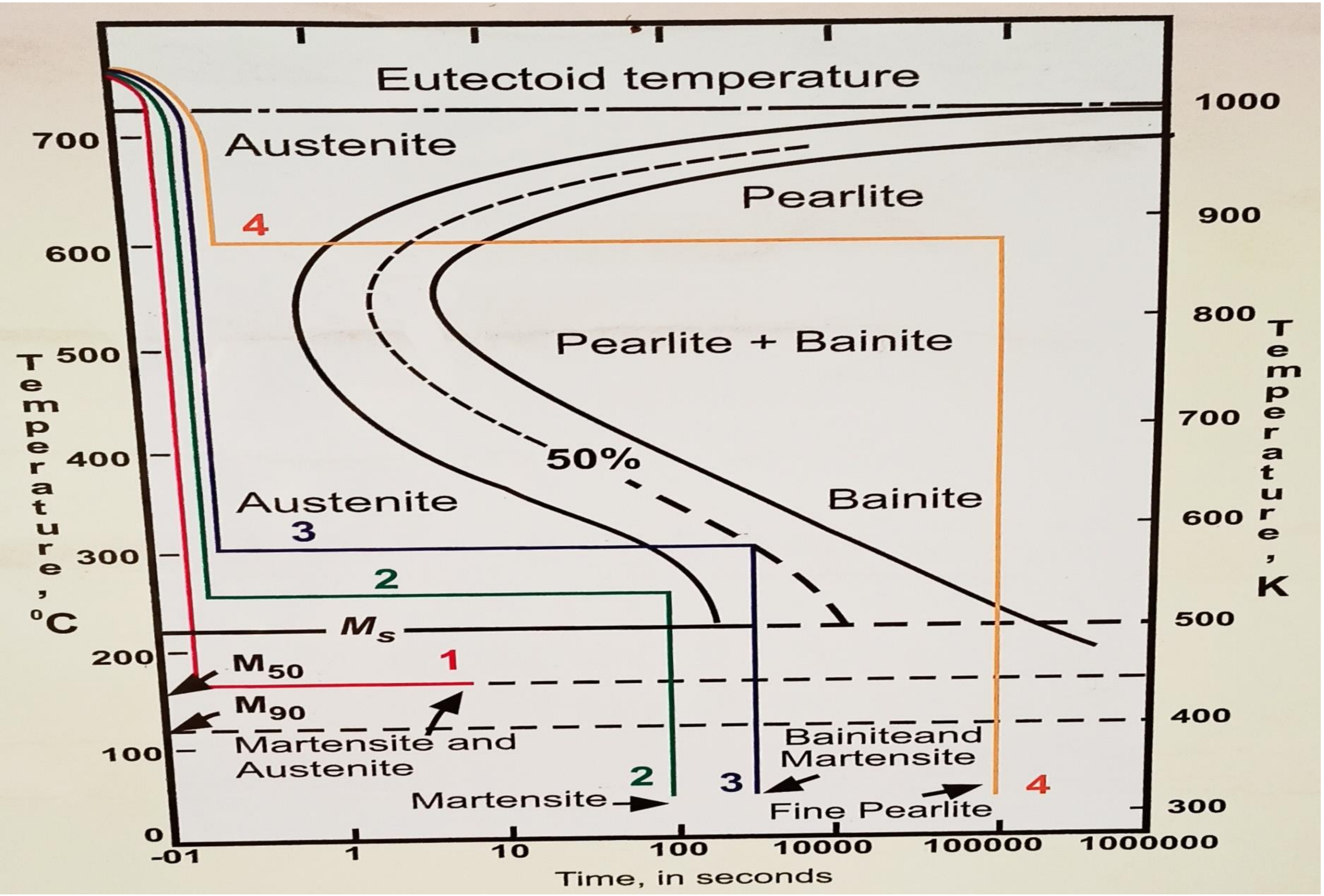
Heat Treatment of Metals

MSE-S305

Ankur Katiyar
Assistant Professor, MSME Department
UIET, CSJM University

Time – Temperature – Transformation Curves (TTT Diagrams)



Time – Temperature – Transformation Curves (TTT Diagrams)

Time – Temp^r – Transformation Curves →

① Trans. Temp^r —controls→ nature of decomposed (γ) —decide→ prop^n of steel.

② Kinetics of (γ) transformation —best studied→ const. temp^r not at contin^n cooling.

③ Isothermal (const. temp^r) Transformation (C-curve) →
C-curve can be formed on the basis of experiment

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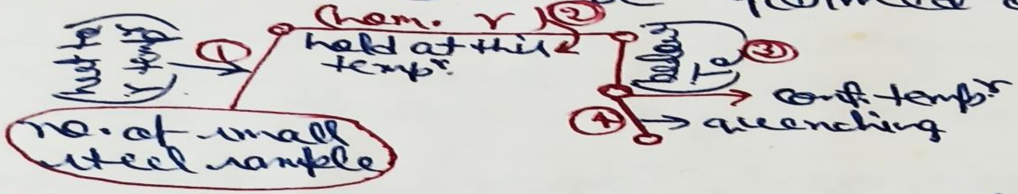

① heat up to γ-ing temp^r (predefined).
② Hold for hom. γ (for long time)
③ put in const. temp^r bath, below Te (for studying kinetics of trans.)
④ quenching of these samples one by one after a definite time intervals.

⑤ quenching —results→ Martensite (by untransformed γ)
* amount of transformed (γ) as a fn of time at const. temp^r can be calculated.

⑥ Long holding time in const. temp^r bath (below Te) ⟶ amount of transformed (γ) inc^n.

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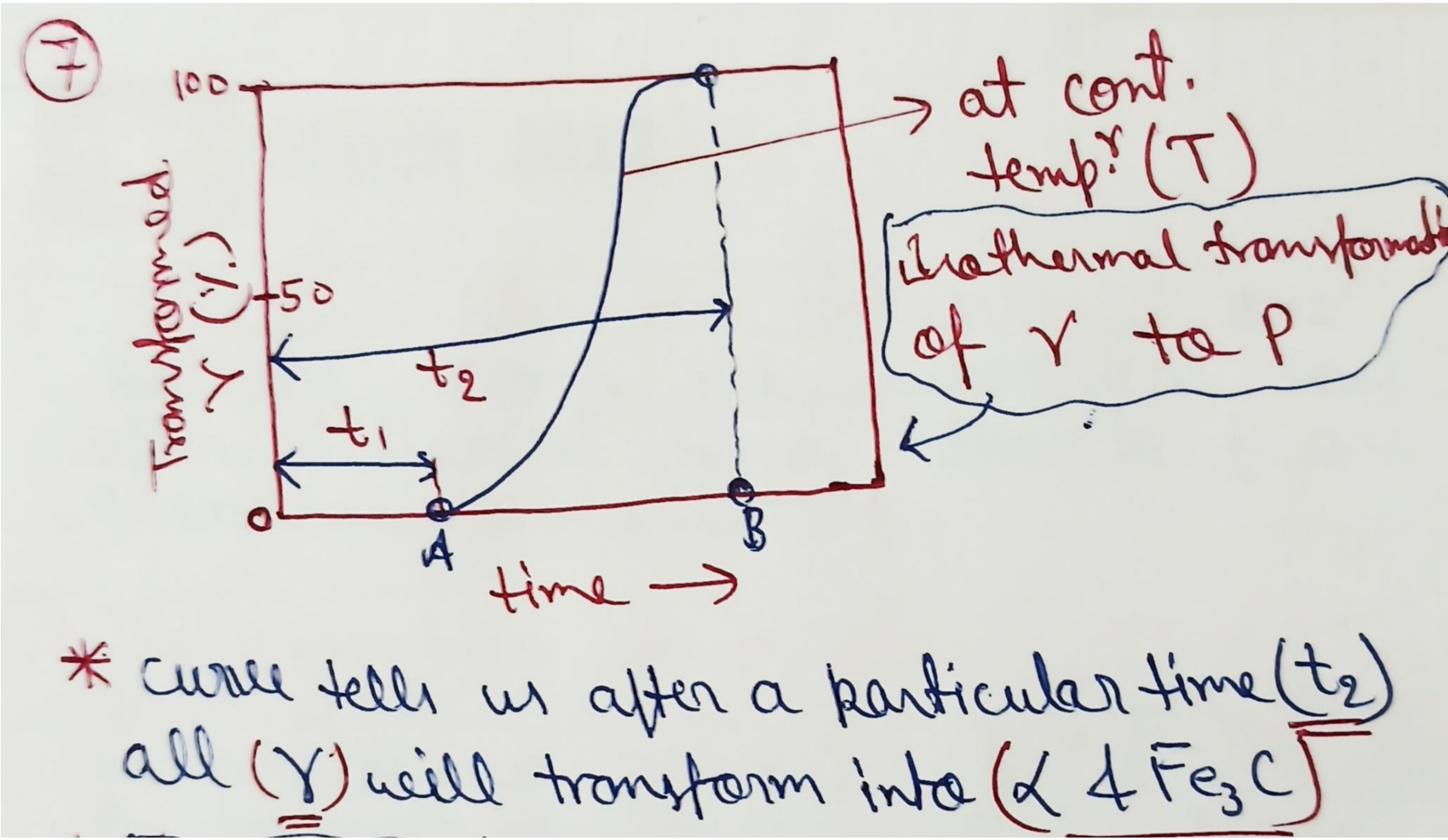

Time – Temperature – Transformation Curves (TTT Diagrams)

31 SAT (11) Fig^r shows the effect of time on the amount of transformed austenite for a given transformation temp.^{r} (T).

(12) It is clear from the fig^r that the transformation of austenite does not start immediately on quenching austenitized sample to a const. temp.^{r} bath.

(13) Transformation of austenite to ferrite-cementite mix^r occurs after a definite time (equals to t_1 of fig^r). This time during which transformation does not proceed is known as incubation period.

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*(14) The magnitude of incubation period provides a qualitative idea abt the relative stability of supercooled austenite. Smaller incubation period corresponds to lesser stability of austenite.

(15) Fig^r has one important limitation, i.e. it correlates the amount of transformed austenite with transformation time for a const. temp^r. Both time & temp^r of austenitic transformation have significant impact on the nature & ~~morph~~ morphology of transformed product.

Notes

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(16) This diag is also popularly known as isothermal transformation (IT) diag. or C-curve. In fact, the TTT curve is an extension of isothermal transformation of austenite diag.

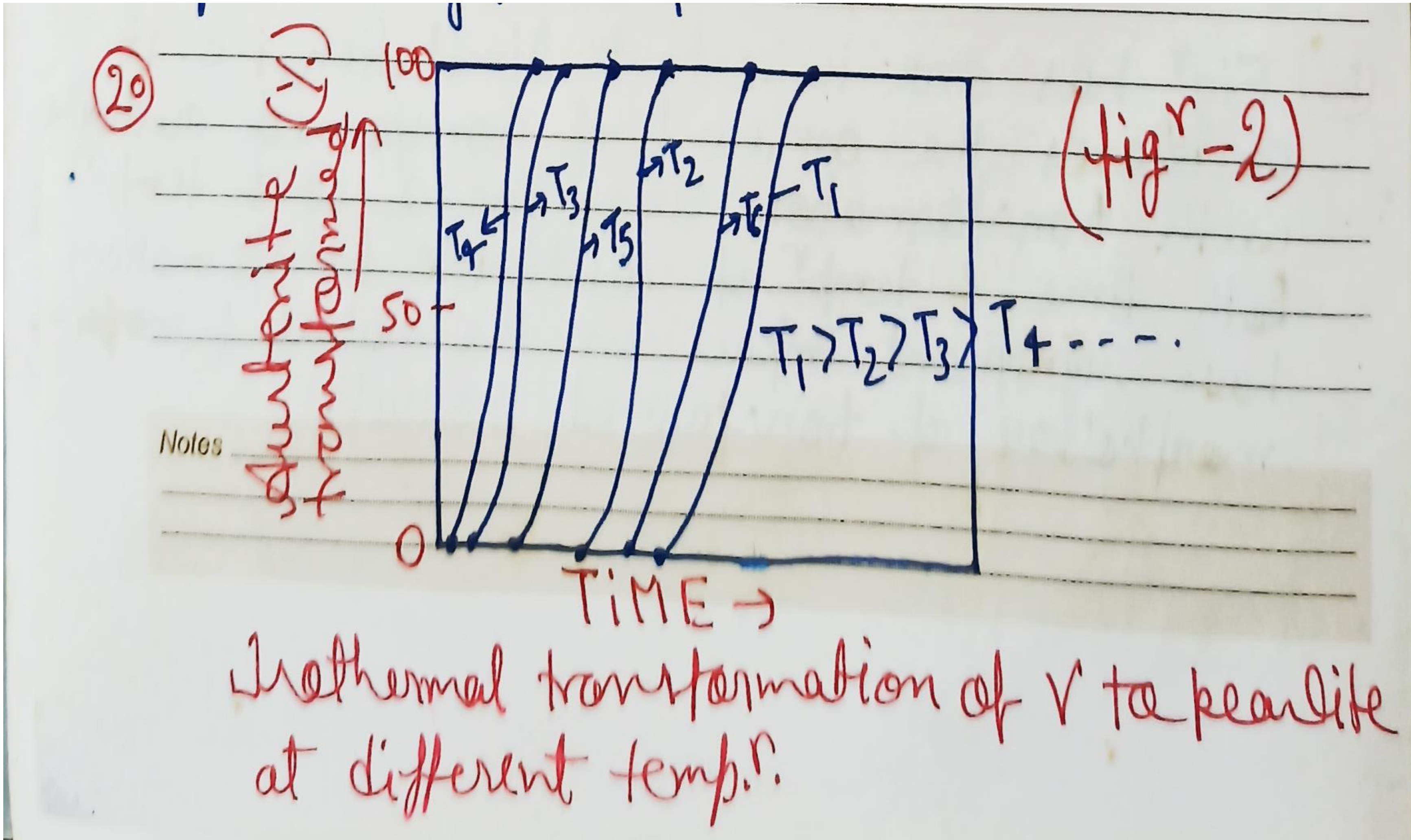
(17) For the construction of the TTT curve for a steel, a large no. of small samples of the steel (Say, eutectoid steel) are required.

Time – Temperature – Transformation Curves (TTT Diagrams)

(18) These samples are treated in a way similar to that already mentioned for the study of isothermal transformation of austenite.

(19) The only diff^{ce}nce is that the same process is repeated a no. of times at varying transformation temp.^{r} instead of a single temp.^{r}.

Time – Temperature – Transformation Curves (TTT Diagrams)



Time – Temperature – Transformation Curves (TTT Diagrams)

Imp:-

(22) The temp.^{r} T_1 is greater than T_2, T_3, T_4, T_5, ---- & is near to the eutectoid temp.^{r}. It can be analyzed from fig. that the higher the transformation temp.^{r}, the more is the incubation period & time req^d for completion of the

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transformation. Incubation period & transformation time dec^n with lowering of transformation temp.^{r}. However, after a particular temp.^{r} (corresponding to T_4), the dec^g trend is reversed & both incubation period & transformation time inc^n again with further lowering of transformation temp.^{r}. The min^m that is observed in the incubation period can be explained as follows. "with dec^n in the isothermal transformation temp.^{r}, the austenite becomes more unstable".

Imp: "The driving force for the austenite to pearlite

Notes

transformation inc^n. Accordingly, the rate of nucleation inc^n."

Time – Temperature – Transformation Curves (TTT Diagrams)

However, "with dec^n in transformation temp^r, the rate of diffusion, which is an exponential fn of temp^r, dec^s." "Transformation rate depends on the overall effect of the rate of nucleation & rate of diffusion."

Time – Temperature – Transformation Curves (TTT Diagrams)

Imp.

(23) "The temp.^{r} at which the incubation time is min^m (T_4) is the one below which the inc in nucleation rate by dec. in the temp.^{r} is more than offset by dec. in the diffusion rate as a result of dec. in temp.^{r}. Consequently, any further dec. in temp.^{r} inc^s the incubation time."

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Time – Temperature – Transformation Curves (TTT Diagrams)

7 SAT (26) For hypoeutectoid steels, ferrite starts separating out from the austenite as soon as austenite is cooled below the upper critical temp^r (Ac_3). The amount of proeutectoid ferrite dec^n as austenite is undercooled more & more below the upper critical temp^r. After a certain degree of undercooling, austenite will transform directly to pearlite. On further cooling, there will be no surplus ferrite.

(27) Similarly, cementite is separated out in hypereutectoid steels from austenite on

8 SUN cooling below the upper critical temp^r (Acm). The amount of cementite dec^n with inc^d degree of supercooling & finally reduces to zero when austenite is cooled below a particular temp^r.